CHAPTER VII.

The Physical Effects and Biological Action of Light Energy. Skin, Circulation, Nervous System, Metabolism.

The Physical Action of Light Energy.

When a wave of any kind strikes an obstacle that is much smaller than the wave length, the wave gets by the obstacle without much difficulty. For example, an ocean wave of 60 feet in length is not troubled by a stake one foot in diameter, by reason of the fact that 60 such stakes would be required to make a wave length. The stake would throw no shadow behind it upon the wave. When, however, the wave length is of the same order of magnitude as the obstacle, the wave does not get by unobstructed, but on the contrary is broken up, reflected or jostled out of existence by the obstacle. A one-foot stake at the mouth of an ocean river would stop waves of 3 or 4 feet in length, or cause a shadow beyond. When light of ordinary visible wave length strikes a molecule which is a very minute obstacle, the wave length is long by comparison with the molecule and goes smoothly on with but little absorption, or else is smoothly reflected with but little absorption; but when ultra-violet light is used, the wave length is sufficiently short to make the molecule, or molecule groups, interfere with and break up the waves, more or less. This breaking up of waves involves imparting energy to the molecules and possibly the disruption of molecules with that energy. The higher the frequency of the oscillating light corpuscles the more likely this is to occur. Groups of molecules are much

more likely to be affected than individual molecules, just as a disruptive action would be more marked from the impingement of waves of suitable length upon a group of persons than upon a single individual, that is, in the jostling and general shaking up to which they would be subjected. The individual might be passed by as the individual molecule by the longer wave lengths. It is possible that there may be some particular sympathetic resonance between atoms and light frequencies, as, for example, between oxygen atoms and ultra-violet light frequencies.

The following theories and facts are generally accepted throughout the scientific world to-day, and help to elucidate the problem of the action of vibratory energy. All matter, whether organic or inorganic, is in a state of continual motion as regards its molecular or atomic structure. As we go up or down the scale this motion increases or decreases as we go up or down the temperature scale, until it theoretically ceases at absolute zero. The motion is vibratory and depends, so far as its changes are concerned, upon the vibrations in the radiant energy acting upon the body of which the molecules are constituents. When the vibration is of sufficiently high frequency, the molecules break down into simpler forms, and the more complex the molecule, the lower is the frequency of vibration necessary to produce this result. In the ethereal vibration of radiant energy, the temperature of the body is raised. This Bean[1] regards as proof that one form, at least, of molecular vibration is induced by an ethereal vibration. The physician's conception of light should not be from the point of optics and concern the visual frequencies only, i.e., from and including the red, to and including the violet, but must embrace the invisible part of the spectrum also. That mysterious region known as the ultra-violet is of equal interest to the physicist and physician, as is also the invisible region below the red.

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[1]William H. Bean, Ph.D.: A theory as to the Roentgen Ray Action upon Malignant Neoplasms. Advanced Therapeutics, May, 1902.

According to Langley, the energy of the spectrum is contained as follows:

Ultra-violet region	1/100
Visible	19/100
Thermal beyond the red	80/100

But as the visible contains much heat, the energy called light is after all very small. It is an established scientific fact that many chemical actions will not take place until a certain temperature is reached, which means the attainment of a certain molecular vibration period. Others again may be brought about by exposure to light, which may or may not change the temperature, but which manifestly must have influenced the molecular vibrations. This action is shown to vary with the different parts of the spectrum. Photobiology has established, for example, a bactercidal action for the middle third of the ultra-violet region, the ability to excite tissue reaction also to the ultra-violet, but the exact locality not determined; a quieting action upon the nervous system to the blue frequencies and apparently an increase of muscular power under their influence. There is also apparently an exciting or stimulating action upon the nervous system from the frequencies of the red region. These varying effects are due to the varying wave lengths or the varying frequencies of vibration. From the action of a complex of all of the frequencies, there is an influence upon molecular activity. In considering the phenomena of the vibrations of sound and the laws governing it, it is well known that to produce a musical note, it is necessary either to strike the body capable of giving it out, or to have it placed where it may receive the influence of another vibrating body. For this latter effect, however, the vibrating body must be of the same pitch or an even multiple of it, and the vigor of the response depends for one factor upon the approach of that multiple to unity.

Bean advanced the theory that a restorative change might be established in a pathologic cell-like cancer cell, for example, by which instead of being destroyed, its character

may become so altered that it becomes again a normal cell. Such a change he attributed to the action of the Roentgen ray. A single X ray impulse is in every respect an ultra-violet light frequency, but there the similarity ends, for the oscillating corpuscles of ultra-violet light are rhythmic and continuous, while the X ray is a discontinuous, infrequent and solitary pulse. The proper atomic motion of a cell, for example, should be stimulated by being in synchronism with an ethereal vibration, whose period of vibration is the same or a multiple of it. In this way, not only groups of molecules but single molecules should be affected. In the longer and slower frequencies, as represented by visible light, are unquestionably to be found the periods of vibrational activity necessary to the maintenance of the living organism in a condition of normal health and function, but when it comes to be a question of diseased processes, a tubercular gland, a lupus patch, an organized exudate, associated with beginning degenerative changes, a sepsis, a syphilitic lesion, it seems necessary, judging from a knowledge of physical laws and physiologic action, as well as clinical results, to have the periods of vibrational activity not only that of groups of molecules, but also in sympathetic resonance with the periods of individual molecules or atoms.

The author believes that the action of condensed light, of which ultra-violet frequencies are active constituents, in diseases characterized by deficient oxidation, the sub-catabolic diseases of Wakefield, is to be accounted for on physical grounds by the fact that there is a sympathetic resonance between the vibrational activity of the oxygen of the blood and the periods of ultra-violet frequencies. It has been established by Cornu that the ultra-violet frequencies from the sun are absorbed not by the varying constituents of the atmosphere, such as the watery vapor, but essentially by the oxygen and the nitrogen of the air. The swing of the oscillating corpuscles of the penetrant chemical frequencies have either the same periodicity or rate of vibrational activity as an oxygen atom, or are a near multiple of the nor-

mal atomic action. In other words they are in sympathetic resonance. It does not seem to admit of question but that the essential principle of chemical action and vital activity, viz., motion, molecular or atomic, is one and the same thing. They blend almost imperceptibly, the one into the other, at a very great many points. Granted, as the author has assumed, that the molecules of a body, either inorganic, organic or protoplasmic, have a motion dependent upon ethereal vibration, and that the atomic constituents of the molecules of these substances or bodies have a rate of vibrational activity or motion peculiar to the molecule to which they belong, then it follows that this rate of vibrational activity or atomic motion must be influenced by the right kind of vibrational activity of the ether. The range of this vibrational activity must be compatible with the integrity of the molecule itself. The breaking up of the higher frequency of the oscillating light corpuscles, as they encounter the swing of the oscillating atoms or molecules, results in an impartation of energy to the molecule, or there may be a disruption of the molecule as the result of that impartation of energy. It seems very probable that both physical actions take place from the administration of concentrated and intensely chemically active light frequencies in a process such as lupus vulgaris, for example.

In the ability of the ethereal vibrations of radiant energy, light and heat, to establish responsive or synchronous motion in the molecule of a given cell, motion peculiar to that of the molecule in question, must be found the rationale of their action. The response of a given atom or molecule may be only sufficient to secure the proper maintenance of normal equilibrium, as under natural conditions of exposure to radiant energy. But when intense chemically active light energy from near its source is localized and concentrated for prolonged periods of time over a dehæmatized region or lesion, something more happens than the normal responsive molecular motion of the molecules or groups of molecules, as is evidenced by the nature of the regressive and productive

tissue changes as well as clinical results. If a cell is not irreparably damaged, then by the return of the normal atomic motion of its constituent, it becomes the seat of renewed life and activity. If the converse is true, the molecular agitation resulting from the action of the very short and high frequency light vibrations must still result in a stimulating action upon the surrounding undegenerated tissue tending to the absorption of the débris of degenerated cells. In the case of bacterial growth or abnormal cells, they are so agitated and worried by the jostling activity of the light corpuscles as to be compelled to deliver up their energy, and eventually are put out of commission, as it were. To this end successive applications are required as there is no question of immediate destruction of bacilli or correction of abnormal cell activity.

It was pointed out by Bean that the difference as regards activity is comparatively great between a cancer cell and an epithelial cell, while as regards constitution, comparatively slight, and that the tumor cell represents a tendency to return to a more primitive form, rather than to an advance in the developmental scale. In this same connection he states that a similar suggestion might be seen in the chemical phenomenon of physical isomerism. He reasons, therefore, that the atomic movements of one are not greatly different from those of the other, and that an ethereal vibration favorable to the one would be corrective toward the other, providing it were strong enough to affect it at all, which is not the case with ordinary light and heat in malignant processes. The ability of a given energy, the X ray or the higher frequencies of light, for example, to produce a return to the proper atomic motion of a cell, providing it had not wholly departed from it, is the physical explanation put forward by Bean for the effects produced by the X ray. In his opinion their action appears to be a corrective and not a destructive one. If the theory advanced by Bean is correct, their action by reason of their physical characteristics is that of a sudden release of energy, which starts into

activity the diseased cell or cells which have departed almost wholly from their proper atomic motion, just as a sudden noise arouses the quiet sleeper.

The frequencies of light energy, however, have not only the same period of vibrational activity, or a near multiple of the vibrational activity of the atoms of cells, but also a rhythmic flow which renders them a safer molecular stimulant than the X ray, and one which should preferably be chosen in all conditions other than malignant. In some of the milder manifestations of malignant disease, the more superficial epitheliomas, for example, the departure from normal cell life, or normal atomic motion is not so great but that the periods of the ethereal vibrations known as light can favorably affect them.

There must be a different period of atomic motion for a giant-celled sarcoma, for example, to that of a degenerating cell, requiring, so to speak, a more sudden and violent expenditure of energy than the latter. Nothing is to be gained by knocking a man down when a soft word will answer the purpose. Similarly, a sudden and violent expenditure of energy, as of the vibrational activity of the X ray, is to be condemned when the synchronous vibration or sympathetic resonance of light frequencies will suffice. The former may and does produce severe dermatitis with necrosis, and an effect even upon deeper structures. This is unquestionably due to the violent action of X ray impulses. The poorer the vitality or body condition the less is the power of resistance, and the greater the damage. Chemical light frequencies also produce a dermatitis, but one from which recovery is easy. These are not powerful enough to produce responsive atomic vibration in the cancer cells, nor for that matter is the X ray, as we know and use it, in the more profound and deep-seated lesions of this character.

As yet it is impossible to say just what periodicity of vibrational activity or frequency of light vibrations is required to influence the periods of vibrational activity of the cells of different kinds of tissue.

That this is largely theoretical is true, but from a knowledge of physical laws, it is a theory that seems very near the truth. It is the high and short frequencies, those of great chemical activity, which influence so profoundly cell action. In diseased processes other than malignant there may be no question of a departure from normal atomic motion on the part of the atoms of a cell, only a more or less profound diminution of it.

The atom which has ceased to swing or vibrate, as it were, is hopelessly extinguished, but just so long as there remains the slightest atomic motion, it is possible, by the action of an ethereal vibration of the right period, to stimulate it into renewed activity until once more it enters into its normal motion. If waves interfere (and waves represent definite periods of vibrational activity) by odd multiples of half wave lengths, they destroy each other, or if they hit matter in these odd phases they destroy themselves, but if they strike matter in even phases they do an incredible amount of work. They sustain every activity on earth, and alone keep up life.[1]

Were light frequencies destructive they would destroy not simply inhibit bacterial growths. On bacteria outside of the living body they do possess a destructive power which indicates only that in the living organism the conditions of atomic vibration around them are of such a nature as to prevent the immediate loss of their own atomic motion. It seems rational to conclude from the nature of the physical action of the short and high frequencies of light, i.e., their jostling activity by which they agitate and shake up small things like atoms, involving also a chemical change, that the micro-organisms would lose some of their power or virulence, and that successive applications should ultimately deprive them of their energy, increasing at the same time the physiologic resistance of the organism. Bean reasons that with the X ray they would either take on an increased

[1]Larkin: Radiant Energy.

growth or not be affected at all, and that the former would indicate a responsive atomic motion and the latter simply a failure to respond.

To the author's mind an inhibitory action seems more likely to ensue, in so far as bacteria are concerned. By inhibition is understood a reduced or arrested nutrition. This is a result of the chemical change brought about by an undue atomic motion or agitation.

The superficial cells of an ulcerating tumor do not, under these forms of vibrational activity, show any evidence of a destructive action: on the contrary, they present an appearance of increased vitality. In developing his theory Bean states that probably only the younger cells are favorably influenced by the action of the X ray, and that the mature tumor cells have probably so far departed from their normal condition, i.e., atomic motion, as to be uninfluenced by an expenditure of energy, such as the X ray, that any changes to which they are subject will depend for the most part on the nutrition they receive. If the younger cells return to normal periods of vibration, and the older cells undergo nutritional changes, a shrinking or atrophy of the tumor mass will follow which is very often the case, a firm but smaller mass remaining at the site of the tumor. When there is a complete disappearance of the mass, he believes it to be due to a phagocytosis, in connection with the atrophy, a condition which at the time of his exposition of the subject he was attempting to determine by microscopical studies.

There can be no question but that there is a similar physical action of the chemical frequencies of light, since the physiological action and the nature of tissue changes established by its use are of the same order. But there is lacking the harsher effect, due in all probability to the more sudden and consequently energetic stimulus to atomic motion from the irregular and infrequent X ray impulses. The constant regular vibration of steam cars, for example, is more tolerable than the jerking and jarring produced by

the frequent starting and stopping of the street car. Different effects follow, and while the latter might be serviceable to a sluggish, hepatic circulation, for example, it could not be advised for an essential neurasthenia. It is by reason of this difference in physical action that the frequencies of light energy are of no avail in malignant processes save in the more superficial conditions of comparatively recent standing. In recent conditions, the departure from the normal atomic motion must be very slight, hence the brilliant results obtained. In this way then a restorative change may be established in a pathologic cell; not in destroying, but in altering its character by restoring it to a normal period of vibration or atomic motion. This may follow the use of other forms of energy than light, or, as instanced, the X ray. It may and unquestionably does follow the exhibition internally of some forms of medication of which strychnia is a notable example. The various frequencies of light vibrations produce without doubt varying differences in effect upon cells.

The analgesia, which is produced by the concentrated, visible chemical frequencies of light, may be induced by a continuous, harmonious vibration, which, judging from effect, has served to tetanize as it were, and exhaust the motility of peripheral nerve elements.

From the physical properties of light energy and its physical action upon a body endowed with a vito-chemical constitution, as is the living organism, follow chemical, osmotic, and molecular changes or physiological action. So far as the chemical end of the spectrum is concerned, this physical action seems a rational one. But for that matter all the visible frequencies are chemical as well as the invisible beyond the violet, and the same is true at the other end of the spectrum. It is only that certain frequencies, i.e., from the blue and above, are more intensely active in this way in relation to the living organism, at least so far as known. In normal conditions of the living organism, the higher chemical frequencies as used therapeutically in con-

centrated light energy, are not essential but only active as they exist in diffused sunlight. When physical conditions, as they relate to light and atmosphere, render them intensely active, and when the conditions of the living organism render it especially vulnerable, i.e., in conditions of more or less depressed vitality, untoward results follow. This is forcibly shown in insolation or sunstroke. There is some evidence also that in prolonged unbroken periods of sunshine, with atmospheric conditions favorable to more than normal diffusion of the chemical frequencies, i.e., less active absorption before reaching the earth's surface, that nerve and mental states, where predisposition exists, are profoundly and unfavorably influenced. In an experience extending over 10 years among the insane, it was a matter of common observation, that an untoward influence was exerted over the mental state of patients under these physical conditions. In addition the greater prevalence of both suicide and homicide has been noted by the author over a period of 30 years, as well as by others, during the prevalence of such physical conditions. The question arises what is the influence at work to produce such an intense excitability of the cerebral cortex or to so profoundly influence conditions of nerve depression. There must, however, be considered all of the physical conditions, not only that of radiant energy, but relative humidity and atmospheric pressure as well.

Is the cerebral cortex unduly stimulated especially in those predisposed, by the frequencies of the red end of the spectrum? Are the nerve centres unduly depressed by too profound activity of blue or chemical light? There seems enough evidence to find ground for the questions. Some time the relation of all the observed facts as to the relation of health and disease to all physical conditions will be unravelled and formulated. Whether man with his peculiar constitution, his desires and aspirations will be any better off, physically, mentally or morally, for the knowledge, is another question. Still it is true that life has been greatly

safeguarded against many conditions of disease by reason of a definite knowledge of the relation between cause and effect.

Be this as it may, the physiological action of light, and not only the need but the dependence of the human species upon it for continued existence, remains unchallenged. The theory and practice of General Pleasanton of "blue glass" fame was not without a scientific basis, building as he did his sun rooms with every eighth pane of blue. But in common with all new theories and practices, it failed of sufficiently accurate scientific knowledge and careful discrimination. To-day the unparalleled work of Finsen, as well as that of others, places us on surer ground.

Light energy causes contraction of protoplasm, and acts directly upon the blood, increasing thereby its oxygenating power. The periodicity of the vibrational activity of the higher light frequencies and their periodical relation to the vibrational activity of oxygen atoms, and also the fluorescence of the blood and of the lymph serum, furnish aboundant supporting and corroborative evidence of the physical and physiological action of light energy. This is further substantiated by the intimate relation existing between the normal organism and light energy, as well as by a very considerable experimental work and clinical data.

The Decomposing Power of Light.—Tyndall showed that if a beam of solar light be sent along its axis through a wide glass tube containing a quantity of the vapor of nitrite of amyl, which prior to the entry of the beam was as invisible as air, that upon the entry of light, a cloud precipitated on the beam. This is due entirely to the waves of light which wreck the nitrite of amyl molecules, the products of decomposition forming innumerable liquid particles which constitute the cloud. Many other gases and vapors are acted upon in a similar manner. This decomposition is not produced by the frequencies of the greatest energy in the

solar light. The infra or ultra-red frequencies could be gathered up and sent through the vapor like a beam of light, but though possessing vastly greater energy than the light frequencies, they fail to produce decomposition. To effect this a suitable relation must subsist between the molecules and the electric vibrations or waves of light. The photographer fearlessly illuminates his developing room with light transmitted through red or yellow glass; but he dares not use blue glass, for blue light would decompose his chemicals.

And yet the waves of red light measured by the amount of energy they carry, are immensely more powerful than the waves of blue. Tyndall pointed out that it was misleading to term the blue rays chemical, for, as shown by Draper and others, the rays that produce the grandest chemical effects in nature, by decomposing the carbonic acid and water, which form the nutriment of plants, are not the blue ones.

When it is a matter of decomposing the salts of silver and many other compounds, the blue rays are the most effectual. These short and higher frequencies or weak waves, as termed by Tyndall, can produce effects which the longer, slower or strong waves are absolutely incapable of causing by reason of their periodic motion.

It is the accord between the vibrations of the voice and those of the strings of a piano which cause the latter to sound when singing with it. Were this accord absent the intensity of the voice might be quintupled without producing any response. But when voice and string are identical in pitch, the successive impulses add themselves together, and this addition renders them in the aggregate powerful, though individually they may be weak.

In a similar fashion the periodical strokes of the oscillating swing of the light corpuscle accumulate until the atoms upon which their tuned impulses impinge are jerked asunder and chemical decomposition ensues.[1]

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[1]Tyndall: New Fragments.

The Action of Light Energy upon the Human Organism.

The general action of light to-day rests largely upon hypothesis. From its principal action outside of the living organism and from the constitution of the latter, as well as from its known action upon plants and the lower animals, a certain amount of speculative theory is permissible. One mode of action is, however, firmly established and that is the action upon the skin. The well-known physiological action of stimuli, chemical or mechanical, in exciting either direct or reflex nerve phenomena, in relieving local congestions, influencing absorption of inflammatory products, need only be instanced to indicate that if no other tenable interpretation is offered for the action of light upon the living being, the known action upon the skin offers a rational explanation of many of the phenomena produced through this agency.

The action of light energy upon the skin, however, is scientifically established. It is certain, clear and precise and stands as a basis for future study and investigation of the action of light upon the general organism.

The Action of Light Energy upon Normal Skins.—In a previous chapter the passing and occasional reaction of the chromatophores to light radiation has been considered. This is to be distinguished from the more or less permanent pigmentation to be seen both in men and in animals and in the parts of the body exposed to the action of light. When the skin containing cells which produce melanin, a melanotic brown pigment formed only by the cells and not by the interspaces (melanoblasts), is exposed to the action of the solar light, the melanin or pigment is developed there, from the more abundant nutriment received under the stimulus of the light energy to the cells. In this way the tanning of the skin in those exposed to the constant action of the light, is produced. It may proceed to a sepia-brown coloring of considerable permanency. In those constantly exposed to the action of light it never disappears.

Pigmentation, the Skin's Protection against Light Energy.—Evidence of this is to be found in the dark, almost black coloring of peoples or races of tropical climes where they are always exposed to strong insolation. The parts of the body exposed to the action of the light are always darker. The same is true of animals. The curious fact was observed by Wedding[1] that light and parti-colored beasts, cattle and sheep, when fed on buckwheat if exposed to sunlight broke out in blisters. The parti-colored beasts showed the skin condition in the light parts; the dark parts remaining unaffected. Beasts kept in the dark and fed on the same food remained healthy. Wedding smeared a part of a cow with tar. As a result the eruption only appeared upon the untarred part of the skin. This is supposed by Tappeiner to be due to the fact that through this food (buckwheat) substances get into the body which are capable of fluorescence, i.e., when exposed to the action of light they absorb energy of radiation at one degree and emit it at another. This action of fluorescent stimulation is considered more in detail in the chapter devoted to that subject. Freund[2] in this connection reports an interesting and corroborative instance of the protective action of the pigment of the skin against light. He came by chance upon a dark complexioned man who for many years had had vitiligo patches upon the body and face. This man after a long walk over the Grosslockner glacier, developed violent inflammation (erythema) in vicinity of the white patches on the face but in those regions alone. Nowhere else was the skin affected. This protective pigmentation may be acquired deliberately as was done by Finsen,[3] who painted a ring around his arm with India ink and then exposed the arm for three hours to very strong light, after which the paint was removed. The skin, which at first seemed quite normal, showing only some redness at the edge

[1]Verhandlungen der Berliner Gesellschaft für Anthropologie, 1888, p. 57.
[2]Freund, Radiotherapy and Phototherapy, p. 420.
[3]Hospital stidende, July 5, 1893, Journal Physical Therapeutics, January 15, 1901.

of the belt, became red and inflamed all over, save in the area covered by the ink, where it was white and normal. After several days the redness disappeared and the skin became pigmented all over the area which had been red and inflamed. He then exposed the same arm to sunlight as before but without the India ink belt, with the result of the white belt becoming inflamed while the pigmented skin around it remained unaffected. The experiment is a most conclusive one, the same arm and the same skin having been subjected to the action of the solar light. Different skins react differently and a comparison to be of scientific value should be made upon the same subject. This reaction is a matter of common occurrence in individuals in those parts of the body unprotected by clothing under the influence of strong solar light. In the use of light in the treatment of skin conditions, this pigmentation serves to prevent the same absorption by the skin and reaction from the use of strongly chemical light in subsequent exposures as takes place in the first exposure. A practical point just here might be made, viz., to make a prolonged application at the first sitting in order to profoundly influence the pathological condition before nature turns her armed force of melanoblasts against further exposures. Finsen's experiment not only proves the importance of the skin pigment as a protective against light rays, but affords at the same time an explanation of the much disputed point as to the reason of the color of the negro's skin.

Action of Light Energy upon Normal Skin.—Acute lesions are thus produced due to the action of light upon the skin. These may be induced by sunlight, solar erythema or by the action of electric arc light, arc light erythema.

The Sunburn of Glaciers.—The phenomenon has been carefully described by DeLong,[1] Klutschack,[2] Nordenskiold,[3]

[1]The Voyage of the Jeannette, London, 1883.
[2]Als Eskims unter den Eskimos. Wien, 1881.
[3]Den Andra Dicksonska Expeditionen till Grönland, Stokholm, 1885.

and Widmark.[1] After a course upon the ice of glaciers or in the midst of snows despite the very low ambient, and although not suffering from cold, tourists or explorers of mountain glaciers or of the north seas present phenomena absolutely analogous to sunburn. The condition is characterized by intense redness of the skin, by heat, smarting, a sensation of burning. This is followed by a desquamation of greater or less abundance according to the extent of the original inflammation of the skin.

Nature of Pathological Change.—The skin inflammation from a glacial burn is followed by a deep but evanescent brown coloring of the skin and differs from the normal production of pigment or tanning consequent upon the action of light. From a single exposure to intense solar or electric light there is produced by the action of the strong light a marked hyperæmia of the skin; the plasma of the blood, in which hemoglobin is dissolved, finds its way out freely through the walls of the capillaries. In a short time the hemoglobin is deposited in the interstices of the tissue as golden yellow hemosiderin. This causes the brownish-yellow color of the skin, which only disappears after this blood pigment has been absorbed, i.e., in a few weeks.[2] The pigment may also be developed from the red blood corpuscles directly. They may pass by diapedesis out of the walls of the blood vessels and shrivel up into pigment corpuscles.

Electric Arc Erythema.—This finds its counterpart in solar erythema or sunburn. The first observation of this action upon the skin reported was by Charcot,[3] who observed it in two workmen. As a source of energy a Bunsen pile of 120 elements was used. The same evening they experienced visual troubles and the next day both of them presented an erythema of the face accompanied by a feeling of discomfort and tension. This erythema, identical with sunburn, was followed by desquamation.

[1]Ueber den Einfluss des Lichtes auf die Haut. Hygiea. Festband, Nr. 3, 1889.
[2]S. Ehrmann, Wiener Med. Wochenschr. 1901, No. 30.
[3]Comptes Rendus Soc. de Biol., 1858.

Charcot voiced the opinion for the first time that the condition was due to the action of the more intensely chemical rays.

The Electric Sunburn of Workmen in Electric Plants.—Defontaine,[1] Maklakow[2] and Finsen[3] are quoted as having made observations as to the production of this phenomenon. It is of common note.

There is also produced a similar erythema in workmen exposed to the influence of electrically operated furnaces, in electric welding for example. It does not matter what the source of light energy, whether the sun, an electric arc or an electric furnace, each time that the skin is exposed to the action of the intense chemical light energy, there are produced the same lesions known as sunburn.

Phenomena of the Reaction upon the Skin from the Action of Intense Light.—The phenomena of this reaction are an increased coloring of the skin from a bright to a copper red, a swelling of the skin accompanied by a burning sensation and pain. In consequence of the proliferation of the horny layer the processes are marked. From exposure to a very powerful source of light energy, the action is much more intense. Blisters are formed, larger or smaller, with ecthymosis and even more or less deep seated necrosis of the tissues. This may, when the action has been intense, be followed by a degree of ill health. This occurs in workers about powerful electric arcs of which in several instances the author has been personally informed. After a few days, this varies with different individuals, the skin becomes less red and the pigmentation increases. The swelling diminishes, the blisters dry up, and desquamation takes place, at first in large flakes, subsequently in smaller bran-like scales. The process is similar to that of scarlet fever.

Time of Reaction.—This reaction to the action of chemical light energy does not take place immediately. In this

[1]Bull. de la Soc. chir de Paris, Dec., 1887.
[2]Arch. d'ophthalmal. IX. 97, 1889.
[3]Mit. aus Finsen's Med. Lys., Vogel, Leipzig, 1900.

respect it differs from the action of thermal energy. This takes place immediately but dies away quickly.

The reaction from light has a latent period, as do the Roentgen rays, but with the latter it is much longer. The length of time required for light reaction to reach its height, depends upon the intensity of the light energy. It is prolonged in proportion to the intensity of the light action and dies away slowly with desquamation and absorption of pigment.

Maklakow, Moeller and Finsen have experimented to determine the period of latency, as have more recently Leredde and Pautrier. Maklakow observed that the effect of a 15 seconds exposure to a powerful arc light (ampèrage not given) was not seen until after 10 hours. An exposure of the skin to the light energy for one minute showed distinct circumscribed hyperæsthesia after half an hour, redness appearing after 2 3-4 hours. From an exposure of the skin for 3½ minutes it became red in 11 minutes and portions of the skin exposed for 5 3-4 minutes reddened after 3 minutes. The experiments of Finsen and Moeller confirmed those of Maklakow.

Before the deduction of a law governing the duration of the period of latency the reader is invited to a study of the very complete experiments of Leredde and Pautrier.[1]

Histology of Solar Erythema.—Leredde and Pautrier made a biopsy (examination of tissue from the living subject) at the level of the skin of the shoulder upon one of their friends who had contracted in boating a severe erythema or sunburn. The biopsy was done 3 days later. Macroscopically, the skin presented only an acute erythema; the color that of a red crab. There was no œdema or effusion.

With a magnifying glass places of separation, a sort of cleavage of the epidermis, were distinguished. When slightly magnified, the epidermis under the microscpe appeared almost normal in disposition and thickness. The

[1]Leredde and Pautrier, Photobiologie and Photothérapie.

corneous layer was observed exfoliated in spots. There were no lesions of importance in the derma: it appeared richer than normal in cellular elements, and there was a distention of its connective tissue bundles. With a higher magnifying power the corneous layer was observed a little raised and separated from the granular stratum. It is leaf-like and exfoliated by the superimposed layers. The granular layer is intact and formed of 2 to 3 layers of cells. No important alterations are noted in the rete mucosum. A spongy condition was noted, and the intercellular spaces appeared slightly increased. Some of the cells presented the *état cavitaire* of Leloir. In the basal layer there were noted numerous figures of karyokinesis, much more than normal. The lesions of the derma were of slight importance. There is slight œdema; the connective tissue bundles are slightly separated, the vessels present a very evident state of dilatation. A slight leucocytic infiltration, forming in spots, is observed. The connective tissue cells appear a little swollen and are a little more plainly visible than ordinarily. There is no karyokinesis observed, however.

The lesions are identical with those produced by the light energy of an electric arc, so absolutely similar that it might be supposed that the same agent had been at work.

The skin of the forearm of one of the experimenters was exposed to the action of the light energy from a Lortet and Genoud apparatus. (In this country the Victor lamp is practically the same.) It was maintained regularly at 15 ampères. Between the skin of the exposed arm and the arc itself the quartz containing water chamber intervened and the distal enclosing plate was used as a compressor. This consists of two quartz discs enclosing the water chamber, or instead of discs or plates focal lenses may be used.[1] The experiment was conducted under the same conditions as a treatment of a dermatosis by the energy of the electric arc would be carried out, in order to determine microscopically the mode of action, i.e., the nature of the tissue changes upon

[1]For description see Chap. XII.

normal skin. There was taken into account at the same time the differences which exist between the mode of reaction of the healthy and of the diseased skin.

The arc was maintained constantly at 15 ampères, the time at 17 minutes, and the distance of the compressor from the arc at 4 cm. Their examinations, "biopsies," were made from one-quarter of an hour after the exposure to a period as remote as 8 days. In this way they were able to follow the process step by step. For all the examinations the skin fragments were treated with a saturated solution of sublimate and fixed in paraffine. The sections were colored with hematin, with hematin-eosin, with hematin and with orange, and with thionin.

First Experiment.—The macroscopic observation showed only a moderate roughening of the skin. Microscopically, no important histological modification was noted. The most that could be observed was a dilatation of certain blood vessels, the lumen of which gaped when the vessels were cut transversely.

Second Experiment.—Biopsy made 2 hours after the exposure. In this section there was observed at the level of the region treated a fresh erythematous tint and a very slight œdema, with a very slight loss of epithelium at certain points.

With a low power microscope lens there appeared but slight dermic alteration, while there was considerable alteration in the epidermis, tending to end in vesiculation.

With a little higher power lens an œdema of the derma was observed slightly separating tissue bundles, and perivascular lymphatic spaces. There was also noted moderate cellular infiltration by the lymphocytes. Mast cells appeared in normal numbers. The important phenomena observed is a slight proliferation of the fixed cells, or rather a tumefaction which renders their swollen protoplasm more apparent.

These were the same lesions which were established by Leredde and Pautrier in the histology of sunburn. The

epidermic alterations are more considerable. In places there is a partial exfoliation of the corneous layer; and there are some cells that have preserved their nucleus. In the granular layer there is an almost complete disappearance of the granules. This layer is represented by one or two layers of flat cells, scarcely colorable. There is an irregular disposition of the cells of the Malpighian layer. Above all the spongoid state of Unna and the *état cavitaire* of Leloir were noted. There is a varying intensity of the spongoid state according to the points observed. In places the cells are lightly separated from one another and their filaments distended, while in other points the more abundant exudate has pressed back the cells disposed around it, representing an embryonal vesicle. Very small subcorneous bullæ are noted at certain points, formed by the cleavage of the corneous layer in its union with the mucous body. Such bullæ are filled with granules and anastomosing fibrils, which seem to be of fibrin.

The *altération cavitaire* of Leloir is observed at every stage; the clear perinuclear space is soon increased, while the exoplasm is pushed back to the periphery of the cell. Next there is observed a curious alteration. The centre of the nucleus is deeply colored, around it is an ill-defined vacuole, then the protoplasm colored a pale blue by the thionin, and the whole floating in a little vesicle. Again the protoplasm seems to have disappeared, and there is only found the nucleus and some protoplasmic granules. In other elements the nucleus is no longer colored, and there is found no more than a skeleton of it. At another place a formed but minute vesicle with some cells of Malpighi quite regularly disposed around it, presenting upon one of the sides of the vesicle a cell already partly destroyed, is observed. The nucleus of the latter surrounded with a small band of protoplasm plunges into the vesicle, and is no longer held to the wall of the latter save by 2 or 3 protoplasmic prolongations.

Résumé.—These lesions the spongoid and cavitary altera-

tions exist as well at the base of the epidermis as at the superficial part. The corneous alterations appear, generally speaking, to be a great deal more important. As a rule the Malpighian cells are more voluminous than ordinarily and appear to be soaked with serum. Although in spots the Malpighian layer presents a certain thickening, no karyokinetic phenomena are observed.

There is not noticed in connection with the lesions just described any alteration of the hair follicles. They present no indications of having been subjected to the action of light. Their epithelium is normal, and the fresh coloration by thionin is in marked contrast to that of the rest of the epidermis, which was colored poorly.

It was concluded by the experimenters that this preservation of the epidermis about these follicles is due without doubt to the accumulation of corneous substance in the utricle which protects it.

Third Experiment.—Biopsy made 4 days after exposure to the light energy. There is observed upon the point treated a brownish-red color and a sort of cleavage of the epidermis, which seems raised at certain points, without there being actual vesicles. With the microscope the lesions of the epidermis appeared very considerable while the dermic reaction was but little marked.

The Epidermic Lesions.—There were 2 very different aspects to the epidermic lesions, depending upon whether a portion of the epidermis is situated under a bulla, or beside one. If outside a bulla, the epidermis presented almost no colored nuclei, staining by thionin showing an intermediary coloration in blue and pale violet. With an immersion lens, notwithstanding the cellular limits, and that the nucleus is replaced by a large hole (the vacuolization observed from the action of (1) Roentgen ray, (2) ultraviolet ray, and (3) high frequency discharges), the protoplasm is flattened and the fenestra of the mucous bodies enlarged. Here and there persists a nucleus in general elongated perpendicularly to the epidermis and presenting an

almost normal aspect. Above the altered mucous bodies there is no trace of the granular layer to be found. The corneous layer is quite thick and flaky. It preserves some almost normal coloring reactions. It is noted, however, that in certain points there are found some readily colorable epithelial nuclei, with a distinct reticulation. The protoplasm all around is scarcely or not at all apparent.

The epidermic lesions below the bulla are entirely different in their aspect. There is found an epidermic layer which with thionin colors violet, and which shows on its deep face some papillæ and some interpapillary cones. This layer presents two superimposed zones of different aspects. The more superficial one is very thick, appearing almost homogeneous to a low power lens. With a higher power there are found some nuclei which appear like lymphocytes migrating toward the bulla and a tissue of hyaline appearance. Also here and there, a flattened epidermic cell is outlined in turbid protoplasm. Some epithelial nuclei seem in contact with the bulla. The deep zone on the other hand is formed by an epithelium which has preserved its nuclei, and which is disposed in a single layer above the papillæ, while in many layers it is thickened to form the papillary cones.

The large bulla is limited by an extremely thin corneous layer. It contains a liquid which colors in a homogeneous fashion, and which by the orange G forms a veritable orange lacquer, sprinkled with polynuclear cells (eosinophiles) having large nuclei.

There exists a zone of transition, between the part of the epidermis underlying a bulla and the epidermis around the bulla, where large vesicles near to one another which are not yet joined with the principal bulla are observed. There is seen at first a subcorneous vesicle which is formed in the same manner as the large bulla, of which it presents a miniature in which the phenomenon of diapedesis is not present. There is observed, however, an irregular mass consisting of necrosed protoplasm. The other vesicles are formed in the same manner, but are deeper, they have

no regular limit, their walls are formed by a necrosed epithelium, having a vacant space in place of the nucleus, and presenting the coloring reaction already described.

In this, as in the preceding experiment, a hair follicle comprised in the section preserved its integrity taking a violet stain by thionin as in the normal state.

The dermic alterations are a great deal less important. A frank vascular dilatation is noted, but curiously not of the cellular focus. The connective tissue presents a turbid state. There is a true tumefaction. Under the bulla are seen two papillæ, filled with a homogeneous tissue, from which every vessel has disappeared. By the side of dilated vessels, there is a disappearance of certain others. A slight œdema is also observed, also some eosinophiles in migration toward the epidermis where they are found, also here and there outside of every vessel some red globules are seen.

Of this period, i.e. the fourth day, the gross alterations are epidermic, and it is impossible not to be struck by the differences between the epidermis underlying the bulla and the epidermis situated around the bulla. Leredde and Pautrier find this difference hard to explain, but advance the following hypothesis: In the tissues altered by the action of the light energy, the influence of the external conditions must be much more important than in the normal state, and that as much more as the dermic circulation is profoundly diminished, and as the perivascular changes are a departure from the normal. In these conditions it is fair to admit that wherever the epithelium is not protected it is desiccated. On the contrary, wherever there is liquid, the cells maintain their normal dimensions and are in a more favorable condition of vitality.

Fourth Experiment.—Biopsy made 8 days after the exposure to light energy. Contrary to the preceding periods the epidermis is thick, much more so than in the normal state. The derma presents quite important reactions which are proportional with those of a common inflammation. The thickening of the epidermis is due above all to the existence

of a layer underlying the mucosum, and which represents the granulosum profoundly modified. It is formed by the cells whose long axis is parallel to the surface of the skin. In numerous points these cells are confluent in a manner, indicating the formation of a homogeneous layer. They have very large nuclei, of the character of the nuclei of the mucosum, elongated parallel to the surface of the skin and often surrounded with a vacuole. There are observed in this layer some large granules of keratohyaline and numerous eosinophile cells and granules. Above this layer there is a solid stratum formed of corneous cells, of eosinophiles and of nuclei, the origin of which cannot be determined. These crusts are covered by a thin corneous layer, forming a universal investment. The character of the rete mucosum is remarkable. It is formed of relatively small cells with a very large nucleus. The intercellular spaces of the interior of the rete mucosum are dilated, while in the basal region the cells are heaped up one upon another, especially at the summit of the papillæ, where they are elongated and seem to naturally compress themselves. In all the thickness of the rete mucosum, but especially in the basal layers, there is found extensive karyokinesis in all stages. The preparation, observed the experimenters, could serve as a model for epidermic regeneration. There were no elements in diapedesis in the Malpighian bodies. The basal layer of the latter presents no longer the slightest pigmentation. Every trace has disappeared, and the skin was normally very much pigmented in this subject.

There is established in the derma, principally in the subepidermic part, the state of hyaline tumefaction that was remarked in the third period of the experiment. But there is found in this layer a greater number of vessels, even in the papillæ. These are extremely dilated—even to the formation of veritable lakes of blood. These vessels are bordered with endothelial cells, slightly numerous, but whose protoplasm much drawn out forms a wall. There are to be found in certain points in the endothelium of the vessels some

figures of karyokinesis. All of these phenomena are indicative that there are going on some phenomena of regeneration. Numerous hematin granules are found scattered outside the vessels. The connective tissue cells of the derma present a state of tumefaction which renders them more apparent and some are in karyokinesis. There are noted also here and there some lymphocytes, trying to form little rounded masses to occupy the lymph spaces. The mast cells are also a little more numerous than in the normal state, somewhat irregular in form, elongated and drawn out.

There is not only no trace of pigment in the basal layer of the Malpighian body, but there is also no trace of dermic pigment.

Histological Reactions Late in Appearing.—The important deduction from these experiments is the late appearance of the histological reactions. This slow reaction is specific of the action of chemical light energy. In this it differs markedly from the reaction established by the thermal energy of light. In heat burns the lesions soon disappear.

Freund[1] in instituting a comparison between the effects produced upon the skin by chemical light energy, thermal energy and that of the Roentgen ray, formulated the following laws as to the speed with which the reaction shows itself and the length of its duration: (1) The duration of the period of latency is in inverse ratio to the wave lengths of the active rays; in like manner the effect lasts longer in proportion as the wave length of the active rays becomes shorter. (2) The greater the intensity of the light the earlier does the reaction show itself and the longer does it last. If the intensity is less the reaction shows itself later and lasts for a shorter time.

Moeller[2] studied the subject of the action of light energy upon the skin, with a view of discovering what changes of tissue in the skin observable under the microscope corresponded to the various clinical pictures of ordinary sunburn as well as more severe reactions. In his experiments he used skin from his own forearm, also skin from the head and ear of rabbits. As a source of light energy electric arcs of from 1,200 to 1,400 normal candle-power were used. The same apparatus as that used by Widmark in his investigations as to the cause of the erythema produced by electric light, and similar to the Finsen tube, was used by Moeller, the circulating water absorbing the heat, permitting thereby the activity of the chemically effective energy.

[1]Radiotherapy and Phototherapy.
[2]Quoted by Freund.

To secure various degrees of effect from a faint erythema with a consequent slight discoloration and pigmentation to the more marked changes of redness, swelling, formation of vesicles, necrosis, etc., the distance between the source of light energy and the skin to be acted upon and the time of exposure were varied. Repeated exposures of the same part of the skin to the action of the light were also made in furtherance of the same purpose.

Histological examination was made of specimens taken from the dermatitis of various degrees thus produced and subjected to microscopical examination as follows:

(1) Human skin after slight photo-electric erythema had been produced.

(2) Grayish toned thickened, rigid, but not yet pigmented skin from the head of a rabbit.

(3) Skin from an ear of an albinotic rabbit, hyperæmic, œdematous, dotted with little blisters.

(4) The ear of an albinotic rabbit showing more marked change, swollen on both sides, hyperæmic, showing ecchymosis and blisters.

(5) A piece of human skin, on which a mulberry-shaped, irregular, dark red hæmorrhagic blister had formed from exposure to the light energy.

From a review of the microscopic changes found in these various specimens, 1-5, the following conclusions are reached:

"The first change to show itself in the exposed skin is in

the vessels, which become microscopically more or less dilated. In connection with this the epithelium becomes moist throughout, and there is an abnormal formation of horny matter (parakeratosis of a changed darker color. The prickle-cell layer of the epidermis and the horny layer appear much extended. Within the latter is a deep-colored strip, which consists of horn cells within their nuclei, Fig. 5.[1]

Moeller surmises that the skin, which shows microscopically no other change than a yellowish-brown color, gets its color from the abnormal strip of nucleated cells. When the irritation produced by the light energy is more intense and of longer duration, exudation supervenes which is sero-fibrinous or rich in cells; it may often also contain red blood cells. The depth to which the changes extend are in proportion to the intensity of the light and the different nature of the skin exposed to the light, i.e., human or rabbit.

The extent to which the pores are affected depends upon the intensity of the exudation. The collagenous tissue begins to swell and becomes homogeneous, the epithelium swells, becomes relaxed, infiltrated and raised in bullæ. The interruption of continuity occurs in various places.

In the human skin it occurs approximately on the border line between the granular and horny layers, but this, by no means, precludes the possibility that on other occasions, i.e., with other skins and other degrees of light intensity, the bullous exudation may not arise differently. This would be analogous with the course of pemphigus for example, where in some cases the blisters appear between the cutis and the rete, in others between the granular and the horny layer. With more intense light thrombi are formed in the vessels of the cutis.

"In Moeller's case the contents of the blister consisted of a fine reticulum, containing numerous red blood corpuscles and isolated leucocytes. Everywhere close to the surface numerous light, round blisters are to be seen with a more or less delicate covering membrane and a light centre. This is

[1]Figs. 6, 7, and 8 from Freund, Radiotherapy and Phototherapy.

Fig. 6.[1]

Fig. 7.[1]

Fig. 8.[1]

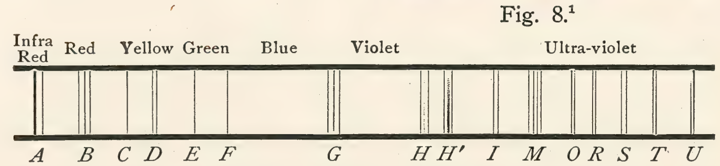

Fig. 9.[2]—Solar Spectrum.

[1]From Freund, Radiotherapy and Phototherapy.
[2]See page 272.

shown in Fig. 7. In some of the horn cells, loosened from the covering of the bullæ, may be seen very distinctly through the swelling of the cells, a longish rod-shaped hole in the centre in the place of the nucleus. In the remaining prickle-layer, too, which forms the base of the blister, cell changes occur, which vary from a simple swelling to a bullous degeneration," as is shown in Fig. 8.

These experiments of Moeller's are a very complete confirmation of those of Freund with the rabbit's ear as to the deeply penetrating action of the ultra-violet frequencies. "The disturbances were, when the light was very intense, most marked and also on the reverse side of the cartilage, in fact because of the larger number of vessels on that side, they were more noticeable there than on the directly illumined side."

Moeller in his investigations proved further that when both thermal (50° to 55°)[1] frequencies and intense ultra-violet frequencies were together active from the source of radiating light energy, they produced, as did the thermal frequencies alone when the ultra-violet were filtered out, more or less cerebral disturbance, sometimes even sudden death. Subsequent to intense radiation of that nature, the autopsy showed the skin of the head to be much swollen and a bloody gelatinous exudation to be present in the subcutaneous tissue. There was discoloration of the periosteum, the cranial bones and the dura, while they were covered with ecchymoses. The vessels of the brain surface were much dilated and upon it were numerous and in part confluent ecchymoses. Upon filtering off the thermal frequencies and exposing the animal to the ultra-violet frequencies alone, there was no central disturbance observable. From these experiments Freund[2] concludes that the action of the ultra-violet frequencies at any depth is relatively unimportant. No change of tissue was to be seen, even in the spongy subcuta-

[1]Not stated whether degrees Centigrade or Fahrenheit, but probably the former.

[2]Radiotherapy.

neous tissue, which is in direct contrast to the condition after exposure to the thermal frequencies.

There is caused by the action of both thermal and ultra-violet frequencies a hyperæmia of the cutis. This, when produced by the ultra-violet frequencies alone, is followed by discoloration and hyperplasia of the epidermis, especially of the horny layer, which in turn prevents further penetration into the tissues.

Pathogeny.—In the production of solar erythema and in electric light erythema, histological reactions of which have been given, the question presented to the experimenter is what part of the spectrum is particularly active. This was first hypothetically answered by Charcot, who placed it at the intensely chemical end of the spectrum. Bouchard[1] in his studies upon pellagra reached the same conclusion.

That solar erythema and photo-electric erythema are due to the chemical frequencies of the spectrum is then a fundamental fact.

In recent years this has been made the subject of experimental investigation and study by Widmark, Finsen, Freund, Bernard and Morgan. Each and all have arrived at the same conclusion.

Widmark[2] was the earlier experimenter. He analyzed the action of the different frequencies upon the skin, using for the purpose the shaven skin of a white rabbit and a water-cooled metallic tube quartz enclosed at one end, at the other half by rock salt and half by glass. This apparatus was used in connection with an electric arc. Through the side of the tube containing the rock salt, both with and without water, the typical erythema was developed followed by desquamation. This was not true of glass simply because of the physical inability of ultra-violet frequencies to penetrate its substance. The experiments of Finsen[3] are very

[1]Recherches Nouvelles sur la Pellagra, Paris, 1862, also Comptes Rendus Soc. de Biol. 1877.
[2]Hygiea, Festband No. 3, 1889.
[3]Mittheilungen aus Finsen's Lysinstitut, Leipzig; also Journal of Physical Therapeutics, Jan., 1901.

prettily illustrative. He utilized the flexor surface of his forearm, where the skin was very thin, placing upon it a plate of rock crystal and a series of bits of glass of different colors held in place by a few drops of glue. He also marked the initials of his name in India ink upon the surface of the same forearm. He then exposed it to the energy of an 80-ampère arc for 20 minutes. For the first half of the time, 10 minutes, he held his arm at a distance of .50 meter from the light of the arc, but as the heat was still very intense at that distance and as it could falsify the results he moved further away and for the last 10 minutes held it at .75 meter. The bits of rock crystal and glass were then taken off and the India ink removed. The skin presented a slight redness where the enumerated objects had been placed and a uniform redness elsewhere. Two hours later the redness began to disappear, the coloring being uniform throughout. Three hours later there was an increased redness but only in the unprotected regions. And this difference between the protected and unprotected skin went on increasing until on the next day the forearm was deep red, hot, sensitive to pressure, while the parts which had been covered by the pieces of glass or by the India ink were white in coloring and absolutely normal. On the other hand that part of the skin surface covered by the rock crystal (quartz) was red and hot as the unprotected part of the forearm. In several days this redness disappeared and was followed by desquamation, subsequently by very marked pigmentation which served as a brown base or background for the white spots which had been covered by the glass and the two letters, N. F. which had been marked in India ink. The experiment is illustrative of the difference between the erythema from thermal energy passing as it did in two hours, and the erythema from chemical energy, increasing after three hours, in the unprotected parts, going on to intense reaction, desquamation and pigmentation. Solar erythema also begins some time after exposure. Likewise in therapeutic uses it is the late reaction which characterizes an expenditure of

chemical light energy. It may appear in a few hours, a day or in 2 days time. When the skin is very thin, very vascular, this reaction appears very quickly, back of the ear, over the mastoid region for example. The author has observed it in that region 20 minutes after the exposure and of increasing severity from 36 to 48 hours.

Still more recent are the experiments of Freund.

Experiments as to Penetrability of Ultra-Violet Frequencies.—Freund[1] endeavored to establish for himself (1) whether the ultra-violet frequencies penetrated the epidermis and reached the lower layers of the skin, and (2) which part of the ultra-violet spectrum had this peculiar property.

The experiments were undertaken in the photo-chemical laboratory of the Imperial Graphische Lehr u. Versuchs-Anstalt, in Vienna, under the supervision of Professor Eduard Valenta. The material used was (1) fresh epidermis from burn blisters, (2) from the bullæ of pemphigus vulgaris, and (3) fragments of epidermis from animals.

Both of the first two were carefully removed with scissors, placed on glass plates, and preserved in the fluids withdrawn from the blisters by a small pipette, for the short distance from the sick room to the laboratory. The latter, like the two other preparations, were kept in a normal saline solution. A spectroscope with a grating was used, instead of the ordinary spectroscope which decomposes light into its constituent parts by means of a glass prism, for, as has been shown, glass is not transparent to the ultra-violet frequencies.

Previous experiments made by Strebel furnished qualitative proof by the lighting up of the fluorescent screen of the power of the ultra-violet frequencies under given circumstances to penetrate the skin, but only spectrographic examination of the penetrating light could determine definitely just which constituents of the light possessed this power. Hence the use of the spectroscope with a grating as was done by Bernard and Morgan in their experiments.

[1]Radiotherapy: Freund, page 428.

The various membranes were spread carefully on one quartz plate and covered with another. Examination with a strong magnifying glass was then made showing that there were no gaps nor tears in the membranes. The quartz plates were then fastened in front of the opening of the "grating spectroscope." The spark light from a powerful Ruhmkorff coil, intensified by Leyden jars, was used; the electrodes between which the spark passed were coated with an alloy of lead, zinc and cadmium (Eder's alloy). The spectrum of the light from this source was then photographed, first with, then without, insertion of the preparations. The opening was 0.2 mm. wide, and the tissues were exposed to the action of the light for 15 minutes.

Under these conditions it was shown that absorption of the ultra-violet frequencies began at the cadmium line, $\lambda = 3{,}260$ Å, i.e., that this line under the given conditions is just recognizable on the film, while the light of the more refrangible rays no longer produces blackening, being, therefore, absorbed. There was no marked difference in the transparency of the three different preparations.

From this experiment Freund reached the following conclusion: "In consequence of this, we may assume with certainty that of the blue, violet and ultra-violet rays, those up to the wave length of the cadmium line, penetrate the epidermis."

Experiments were then made for the purpose of comparing the behavior of dried epidermis with that of moist and fresh normal epidermis. For this purpose, films of almost colorless horn and of horn slightly colored yellow, 0.5 and 0.56 mm. in thickness respectively were used. They were tested by examination under sunlight with the "grating" spectroscope. The yellowish horn, with an opening of 0.1 mm., and an exposure of 80 seconds allowed the light up to the Fraunhofer's line O, = 3,440 Å to pass through; under the same conditions with the colorless horn

the ultra-violet rays were effective up to $Q = \lambda\ 3,287$ Å. These experiments showed that dead epidermis has on the whole the same absorptive power as the living epidermis, but the permeability of colored, that is, pigmented epidermis, was shown to be sensibly less than that of the former.

Still more recently this subject has been studied by Bernard and Morgan in connection with their experiments on bacteria.

This part of the investigation comprised their third series of experiments. These were made to determine what part of the energy of the spectrum was active in exciting reaction on the part of the tissues, and while suggestive, are not yet regarded as conclusive by the experimenters.

The shaved skin of a rabbit, anæsthetized, to secure absolute quiet, was subjected to the spectrum, with the same spectroscopic arrangement as in their experiments upon bacteria, and no effect whatever was produced after an exposure of $2\frac{3}{4}$ hours, with a current of 25 ampères. Guinea-pigs, white rats, frogs, and even a human arm were similarly subjected to the same spectrum, but with absolutely no evidence whatever of tissue reaction.

An additional experiment seemed to show that the rays exciting this reaction exist somewhere in the ultra-violet region. A rabbit shaven on both sides of its body was subjected to the action of the light from a 25-ampère electric arc passing through the water-circulating apparatus. Contact was made with the quartz disc on one side for 5 minutes. Then the other side was exposed in the same fashion, save that a sheet of glass was inserted between the water-cooling apparatus and the skin. The second exposure lasted an hour, and was made with a current of 25 ampères. On the following morning, on the side exposed to the rays through glass for an hour, absolutely no effect had been produced on the skin, while on the side exposed but 5 minutes through quartz and without the intervention of glass, there was a well-marked redness.

This, the author has clearly substantiated in the therapeutic uses of apparatus arranged with (1) glass plates or discs, (2) quartz discs, and also in experiments made upon culture plates, the bactericidal effect being active with the quartz, absent with the glass. The well-known transparency of quartz to the extremely short and high frequencies, ultra-violet, and their loss or absorption upon the interposition of glass, accounts for the results obtained both experimentally and therapeutically.

All rays of the spectrum, save the greater part of the ultra-violet, readily penetrate glass, and any effect obtained with apparatus containing lenses or globes of glass is due to the more feeble penetration of a few of the frequencies on the extreme edge of the violet as it merges into the ultra-violet region. To obtain the maximum action of ultra-violet and blue violet frequencies is to secure the maximum result in the treatment of such pathologies as lupus vulgaris, as has been done by Finsen.

It is then clearly proven that the frequencies which excite tissue reaction are to be found in the ultra-violet region, but it is not yet accurately determined in just what portion of the ultra-violet spectrum they are located.

Chronic Lesions Due to the Action of Chemical Light Energy upon the Skin.—Chronic lesions of the skin are established by the chemical energy of light which manifest themselves (1) by pigmentation, and (2) by vascular modifications.

Vascular Alterations Produced at the Level of the Skin by the Chronic Action of Chemical Light Energy.—Some months after the experiment upon his arm Finsen[1] observed no trace of the intense reaction which had taken place in the unprotected regions. One morning about 6 months after the experiment when at his toilet, upon rubbing his skin he observed that the part of the forearm which had been the seat of the photochemic erythema presented a much more marked redness than the parts which had been protected by

[1]Journal of Physical Therapeutics, April, 1901.

the glass plates. This difference finds its explanation in a persistent dilatation of the vessels and capillaries of the skin following upon the action of the light.

In the author's experience there has occurred a permanent and marked dilatation of all the capillary blood vessels of the inner and outer aspect of both legs, but especially of the inner, in the person of an invalid lady, from prolonged and constant exposure to the chemical light energy from a hard-coal fire. By reason of her profound anæmia and imperfect circulation she was obliged to sit very near the fire for hours at a time, and was in the habit of raising her skirts to prevent their being scorched. In consequence there is not only the dilatation, but also marked pigmentation, and after a lapse of from 4 to 5 years it is as evident as at first. The action of thermal stimuli at this time causes a very prompt reaction so marked as to outline the anastomoses of the superficial capillary vessels.

Finsen established the dilatation of the capillaries in his experiments upon the tail of the tadpole, while Leredde and Pautrier showed it by their examination of sections of the skin acted upon by light energy.

Finsen and Moeller proved by experiment a peculiarity of light reaction corresponding precisely to that observed by Freund with Roentgen ray reaction, viz., that skin which has been exposed to the influence of powerful chemical light energy, blue-violet and ultra-violet frequencies, retains for a long time, months and years after the first light erythema has disappeared, a peculiar predisposition to react with remarkable promptness to mechanical, chemical and thermal stimuli, and also to internal influences, psychical stimulus, for example. This reaction is evidenced by a very quick reddening of the part.

The more active cutaneous circulation established by light is a condition of better function for the skin.

This is true of the physiological action of ordinary sunlight upon the cutaneous covering. In this connection, however, it is the action of concentrated light upon the skin.

It is no longer an acute phenomenon of a common inflammation but a chronic phenomenon of some sort, producing itself after long periods of time. But other tissues are influenced by this action. It was observed by Berthold[1] that the nails, the beard and the hair grew more rapidly in summer than in winter. Finsen[2] inquired of the coiffeurs, and according to them it is a current observation that it is not necessary to shave so often in winter as in summer. It has been observed in Finsen's clinic that both patients and nurses acquired a thicker growth of hair on those parts repeatedly exposed, and for long periods to the powerful electric arc energy. It has also been proven, and it only further illustrates the same phenomena, that amphibia and fishes whose limbs have been broken off grow again more rapidly in the light than in the dark.

The explanation lies in the fact that in the summer, by reason of the abundance of light, the skin is better nourished than in the winter; with the amphibians and fishes there are more active circulatory conditions in light than in darkness.

This action on the cutaneous circulation not only produces a temporary hyperæmia, but, as has been indicated, a lasting one, a condition which unquestionably influences favorably the diseased area, subjected to the action of the chemical frequencies. In all diseased conditions, where the vital processes are below normal, whether accompanied by the presence of a germ or not, as in tuberculosis, the best result is to be obtained by securing a hyperæmic condition of the tissues. To this end, every means is tried to stimulate circulation and to produce the hyperæmia necessary to establish restoration to normal conditions as in a tuberculous lung, joint, gland or skin lesion, or to establish healing, as, for example, in a varicose or tubercular ulcer.

Chemical stimulants in the form of lotions, ointments, even injections are used; the aid of electricity is invoked either to produce the characteristic action of the current, or

[1]Mueller's Arch. für Anat. und Physiol., 1850, p. 158.
[2]Mitt. aus Finsen's med. Lys., Vol. I., p. 118.

by means of it to deposit within the tissues the salt of an oxidizable metal. By the action of light, the same effect is produced, an effect which is both deep seated and lasting. The necessity for this hyperæmia is, if possible, more necessary in tubercular affections than in other pathologies. It is by reason of the deeply penetrating action of light that favorable results ensue.

Applications of typical chemical stimuli are very superficial in their effect. The far-reaching and permanent effects obtained by the light vibrations are comparable to the effects produced by the deposition of salts of oxidizable metals at the anode or drugs in solution or suspension, both anaphoric and cataphoric medication. By the action of the salts of oxidizable metals, far-reaching and lasting results are obtained.

It is believed that the chemical products of the bacteria are accumulated by the action of the light, a condition which is unfavorable to their development. As the chemical frequencies of light, especially the ultra-violet rates, have the power, by reason of their short wave length and very high frequency, to agitate bacteria, shake them up as it were, a physical condition inimical to their vitality, they must by this action be deprived of their oxygen. Such a deprivation would mean an accumulation of their chemical products. Meanwhile the same action which results disastrously to them gives an impetus to the normal oxygenating power of the blood.

There is no radical difference in the mode of action of the different means employed for the production of a physiological irritation. Whatever their nature, they follow a universal law, and the result of their use is both inhibitory and constructive. Bacteria are inhibited, morbid growths due to them resolved, metabolic perversions and their skin expressions overcome, and all the while the beneficent action of light upon the organism as a whole goes on tending to an elevation to the normal standard.

The formation of connective and scar tissue depends

always, whatever its locality or however formed, upon a preceding hyperæmia.

It has been stated by Lang[1] that the pressure employed by means of compressors was the curative factor, and he is responsible for the statement that he has cured lupus by pressure alone. This has not only not been substantiated by any other observer, but it has been proved beyond peradventure that it is the penetrating light, chemically active, which excites tissue reaction and which cures lupus.

But side by side with the vascular modifications, another phenomenon occurs from the prolonged action of chemical light energy upon the skin, viz., the production of pigment. This may be regarded as a process of defence or adaptation. Beyond question it is the act of defence on the part of the skin in relation to the chemical rays. It will be remembered in considering the rôle of light in the pigmentation of animals that the deepest part of their coats is always the dorsal surface, which is the one most exposed to light. Of equal interest and pertinence in this connection are the experiments of Packard and Viré on the cavernous species of animals. (See Action of Light on Animal Organisms; the Influence of Light on Pigmentation.) In man the pigment production appears to be the same in all parts of the body exposed to light. The action is not due to the wind, to sea-air, or exposure to inclemencies of weather, but is one of chronic alteration involving the pigment cells due to chemical light energy. As is commonly observed, it follows sunburn. Both Finsen and Widmark noted a consecutive pigmentation in their experiments. Pigmentation left after exposure to strong light comes from the accumulation of hemosiderin in the interstices of the tissues.

The Rôle of Pigmentation as a Process of Defence.—This is established in part by the more active cutaneous circulation consecutive to the first chemical light erythema.

[1]Wiener dermatolog. Gesellschaft and IV. Internat. Congress f. Dermatologie and Syph., Aug. 2, 1900, Compt. rend., p. 171, quoted by Freund.

The red medium, the blood, absorbs the violet and ultraviolet frequencies more than any other tissue. By reason of the stimulus thus imparted there is increased oxygenating power, i.e., the red blood corpuscles are more richly stored with oxygen. This doubtless serves as an appreciable agent of protection. By reason of the histological changes, i.e., an œdematous, thickened, spongy epidermis, the penetration of the chemical frequencies of short length is prevented. The practical application of this should not be lost sight of in therapeutic applications, i.e., not to repeat an exposure until the reaction has sufficiently subsided; for an epidermis in this condition cannot be transparent to light, that is, permit its absorption.

It is the pigmentation, however, which plays the most important part in the process of self-defence. Finsen and Giard, in France, have both voiced the theory. No better illustration of it is to be found than in the dark coloring of the peoples of the tropics.

Pigmentation as One of the Factors of Natural Selection.—Perhaps there is some evidence of this. It was studied by Böhn,[1] who, in considering the struggle that living beings sustain among themselves and against the diverse agents of the external world, declares that there results from the *ensemble* of these phenomena an impression of harmony. Struck by the rôle played by pigment, Böhn admitted by the side of physical and chemical harmonies, which only reveal themselves after much analysis of biological phenomena or not at all, pigmentary harmonies.

Savants have been struck by these harmonies of colors, and to the minds of Wallace, Darwin, Poulton, Giard, they play an important part in the affinities of beings among themselves and in their relations with the external media. The theory is known under the name of mimetism.

Pigmentation as a Process of Adaptation.—It is probable that pigmentation may be regarded quite as much a

[1]L'évolution du Pigment, loc. cit.

process of adaptation as a process of defence. But even so the two functions run imperceptibly the one into the other.

Leredde and Pautrier are of the opinion that in pigmentation in the animal kingdom and upon the human skin the process may be one of adaptation by which the pigment might utilize the chemical energy of the spectrum, transforming it into energy, which in turn may be utilized by the organism in a form of which nothing is known. They state in this connection an admitted fact, viz., that the sobriety of the races of the tropics is well known, and that the sum total of work of which they are capable is entirely disproportionate to their apparently insufficient ration. The explanation of the difference in alimentary régime between the people of the north and the people of the south, which is always offered, and so far as is known, is the correct one, is that because of the difference of temperature the former require more food to resist the cold than the latter. These authors raise the question as to the light energy, whether it may not also play a part in these phenomena. The author would say that because no such relation is known and proven, the possibility of its truth is not precluded. All about us in nature is a wealth of unanalysed truth. In so perfect and stupendous an organization as the universe, there is an explanation for every observed fact. To the author's mind it seems more than possible that when biological phenomena are more fully analyzed and understood, there will be found a correlation of the first order between the radiant energy of the sun and all the phenomena of life. Reverting, however, to known facts in the wealth of observed phenomena to the minutest detail of the action of light energy upon the skin as studied by Widmark, Finsen, Freund, Bernard and Morgan and Leredde and Pautrier, there is builded a scientific foundation upon which future biologists may hope to rear a superstructure of as carefully analyzed biological phenomena, which in its turn will tend to elucidate the relation of life to light.

The Action of Light Energy upon the Blood.—As an

evidence of the relation between light and life is the fact that certain constituents of animal tissues permit of the free passage of light. This transparency is of practical value in the use of light as a diagnostic agent, a method much in use before the discovery of the Roentgen ray.

Tissues differ in regard to their transparency to light. It is a matter of their structural density and the chemical nature of the layer, but especially the uniformity of the tissue, both as regards the nature of its matter and its density. All of the substances of the living organism are not equally transparent to the different frequencies or colors of the spectrum. For example, the blood transmits the red frequencies but absorbs the more refrangible frequencies. Freund's experiment showed that in the living frog's web, the blood absorbs all the light from Fraunhofer's line H. or wave length 3,964 Ångstroms.

In order to have an actual picture of the transparency of the living tissue to the red frequencies, let the reader place the hand over a source of light, or place a small incandescent lamp within the mouth. Light is used in this way as a test for hydrocele. In the transmission of the longer and slower frequencies in all these instances, the fact that it penetrates the skin is shown. A diamond ring may be made to sparkle when covered with a finger, for example, which is illuminated from above, and even when the finger is covered with white or chamois leather. This was first shown by Dessaignes. Gebhard[1] imbedded a hand so completely in plaster of Paris, in the hollow of which he had placed a photographic plate, that only the back of it was exposed to the luminous energy of an electric arc for 20 minutes. The plate was removed to a dark room and developed. It was blackened, and the outlines of the hand and fingers were distinctly seen. This demonstrates that not only light, but light chemically active passed through the hand.

From the experiments of Gadneff[2] the nature of the

[1]Die Heilkraft des Lichtes, Leipzig, 1898, p. 131.
[2]Quoted by Boubnoff, Arch. f. Hyg., Vol. X., p. 335.

penetrating energy is shown. He filled small tubes with chloride of silver, sealed them hermetically, and then by the aid of a trocar carried them under the skin of living dogs and cats. Some of the animals were placed in captivity in darkness, while others were allowed to run free exposed for some time to the action of the sunlight. In the latter, the chloride of silver was blackened, in the former no change had taken place. Finsen's experiment on his wife's ears not only demonstrates the passage of chemically active light, but proves that the blood interferes with its passage to a very great extent.

Still another experimenter, Darbois[1] showed that a piece of photographic paper introduced into the mouth under the skin of the cheek between two watch glasses was blackened after one minute's exposure to the light energy from an electric arc used in connection with a Finsen concentrator directed to the outside of the cheek.

Solucha[2] filled tubes with strips of silver-bromide-gelatin inserting them under the skin of dogs and sewing up the incisions made to receive them. He used a projection apparatus at 50 to 65 volts pressure and from 10 to 20 ampères current strength. The bromide of silver was seen to be decomposed after one minute. When the tubes were carried down deep into the glutei muscles on the other hand, the sensitive paper was not acted upon, showing that the light did not penetrate so deeply. The decomposition soon set in when similar tubes were placed behind the ear or inside the cheek of patients in the first instance after half a minute, in the latter after two minutes, while when placed behind the forearm or in the fist the sensitive paper was unchanged after 15 minutes. By an increased light intensity, say 25 ampères at 110 volts pressure, the entire body can be penetrated, for under such conditions the sensitized gelatin film was chemically altered even when placed upon

[1]P. Darbois, Traitement du Lupus Vulgaire, Thèse de Paris, 1901, p. 80.
[2]Quoted by Freund.

the opposite side of the body from the part exposed to the light. Solucha for example placed it at the back of the neck, when exposing the throat or at the right side of the body when the light came from the left.

As further proof of the penetrating power of even chemically active light energy, are the experiments of Kime.[1] For a source of light energy the sun's rays were utilized and the light passed through the thorax to the sensitive film placed upon the patient's back.

Finsen observed distinct weakening of a bacteria culture which he placed back of the ear of a white rabbit and through which he passed concentrated sunlight. He also showed that the light passed through the compressed lobe of a human ear could be broken up clearly into all the colors of the spectrum. Strebel[2] utilized the fluorescent property of ultra-violet energy to prove the penetrability of the human skin in the following manner: A piece of skin freed from all fat tissue was fixed between small quartz plates; all of the colored frequencies of light energy were excluded and it was exposed to ultra-violet energy, produced by the induction sparks from zinc and aluminum electrodes. The distance between the skin and the spark was 140 cm. Upon placing a fluorescent screen behind the skin it showed that a human ear compressed between two quartz plates absorbed isolated ultra-violet frequencies completely.

That there is a penetration then not only of energy which affects the visual organs but of the energy which is chemically active through animal tissue, is thus very completely demonstrated. The penetration may take place through tissues of considerable thickness under certain conditions. The ultra-violet frequencies alone barely penetrate the epidermis, even when applied in a concentrated form but when combined with the blue indigo and violet, the complex of frequencies is much more penetrating, being absorbed by the first thick layers of the blood vessels; while the red and

[1]New York Medical Record.
[2]Deutsche Med. Wochenschrift, 1901, Nos. 5 and 6.

infra-red permeate the cutis and pass into the deeper tissues. The tissues of the body to a considerable depth are diaphanous to the red frequencies as is shown by their transmitting effect. With a miniature incandescent lamp of small candlepower it is possible to transillumine the pelvic tissues to within two inches of the umbilicus in a subject of ordinary avoirdupois and thickness of abdominal fat. That these longer and more deeply penetrating waves are subjected to some modification of their motion, a temporary arrest, as suggested by Strebel[1], seems possible. Their wave length is entirely out of proportion to the size of molecular structure and it does not seem possible that the latter would insure their temporary arrest, for when a wave strikes an obstacle that is much smaller than the wave length, the wave gets by the obstacle without much difficulty and in that event little or no energy is expended, therefore little or no work is done.

From this physical law it would appear that in so far as the structural nature of the tissues permits of the transmission of the energy of red light, or the long and slow frequencies there is little or no energy expended or work done in them. On the other hand in their action upon the deeper and more translucent structures the ultimate energy would only heat, as it could not penetrate so far without absorption. The disruption of molecules and consequent effect upon molecular structure is more likely to occur the higher the frequency of the oscillating light corpuscles.

Light is converted into heat waves and perhaps into long electrical waves. The energy of the spectrum is transformed into other forces, the forces which are inherent, viz., electric, osmotic and the vibrational action of molecules or other mechanical energies. A direct action upon the chemical processes and stimulation of the functions of the tissues and protoplasm is established reflexly by exposure to light energy. Light acts as light by its chemical activities alone,

[1]Die bisherigen Leistungen der Lichttherapie. Berliner Klinik, February, 1902.

and the primary action is upon the blood, by which its oxygenating power is increased.

If in consequence of the exposure of large body superficies to the influence of strong light the accumulation of hemosiderin in the interstices of the tissues, that is, the giving off of blood coloring matter, takes place to a very great extent, a certain impoverishment of the elements of the blood and the coloring matter may ensue. As a result the organism may be stimulated to increased functional activity to compensate for this change. This theory advanced by Löwenthal[1] offers a rational explanation of certain metabolic changes which take place under the influence of light energy.

The influence which light energy exercises upon the blood and capillary systems in living organisms is one of great importance. By its action blood vessels undergo a change in form, as has been fully demonstrated by very extensive experimental work. The action upon the blood stream itself, however, is one of absorption and the absorption of energy means the impartation of a stimulus to the functioning parts or whole of the living organism. In this instance the stimulus is imparted to the blood corpuscle and the direct action of the energy absorbed appears to be upon the storer of oxygen or the red blood corpuscle. By the increase of oscillating movement or swing of the corpuscle there must be an increased energy of action according to every physical law. It is the penetrant chemical frequencies, the blue, indigo violet and ultra-violet, that thus act upon the red media. From accumulated experimental data and clinical observation, as well as from a study of the physical laws of light and their correlation to the living organism, is found constant proof of this fact.

Spectrum of Hæmoglobin.—A glance at the constitution of the red blood corpuscle and at the spectrum of hæmoglobin cannot fail to be of interest and value in the study of the action of light energy upon the blood.

[1]Deutsche Med. Zeitung, 1899, No. 72.

Human red blood corpuscles singly are biconcave circular discs of a yellow color with a slight tinge of green; they seem to be devoid of an envelope, are certainly non-nucleated and appear to be homogeneous throughout. Each corpuscle consists (1) of a framework, an exceedingly pale, transparent soft protoplasm—the stroma; and (2) the pigment or hæmoglobin, which impregnates the stroma much as fluid passes into and is retained in the interstices of a sponge. Hæmoglobin possesses some remarkable properties. Although it is a crystalloid body it diffuses with difficulty through an animal membrane, owing to the large size of its molecule. (3) It readily combines with oxygen to form an unstable and loose chemical compound, oxy-hæmoglobin. (4) This oxygen it gives up readily to the tissues or other deoxidizing agents. (5) Its composition is very complex, for, in addition to the ordinary elements present, in proteids, it contains a remarkable amount of iron (0.4 per cent.).

Graffenberger[1] maintains that the mass of hæmoglobin contained in the red blood corpuscle is lessened in the dark and that from a prolonged stay in the dark there is a diminution in the total quantity of the blood.

Marti[2], in his experiments upon rats, established the fact that the deprivation of light lessens the number of red blood corpuscles, and to a less extent the amount of hæmoglobin, while from exposure to strong light continuously, the formation of erythrocytes and also of hæmoglobin was stimulated. Hæmoglobin is then active in the absorption of these chemical frequencies and in the relatively large size of its molecules is to be found a physical condition favorable to the physical action of these periods of oscillating light corpuscles.

The stimulation imparted results in an increased activity of oxygen absorption and the formation of oxy-hæmoglobin. A study of the spectra of oxy-hæmoglobin and metahæmoglobin, both absorption and flame, should be of the

[1]Pflüger's Archives, 1892, Vol. LIII. p. 238.
[2]Verh. d. Congress f. Innere Med., 1897.

same if not greater interest to the therapeutist than it is to the physiologist and pathologist. A glance at the spectrum of hæmoglobin demonstrates that it is no exception to the rule. The general coloring in the case of well-oxidized arterial red-blood corpuscles is scarlet; with venous blood a darker red. A single corpuscle shows a yellow coloring with a slight tinge of green.

Thus in the green, yellow and red coloring is to be found the evidence of the energy of radiation of the emitting or, in this instance, the fluorescent tissues of the body, all of them below the longest wave length of the visible chemical frequencies, or the blue.

Flame Spectra.—In the ashes of almost all organs are to be found the bands, which indicate the presence of potassium and sodium.

Absorption Spectra.—If a solution of blood be placed between the slit of the spectroscope and a source of light, all the rays of colored light do not pass through it—some are absorbed; many yellow frequencies or rays are absorbed by blood, hence that part of the spectrum appears dark to the observer. This should bear a relation to the presence of sodium in the blood, and its constant presence in the spectra of all sources of light. On account of this absorption such a spectrum is called an absorption spectrum.

If sunlight be allowed to fall upon the slit, the spectrum shows a large number of lines, Fraunhofer's lines, which occupy definite positions in the spectrum. These lines are indicated by the letters A, B, C, D, E, F, G, H, H_1, etc., as shown in Fig. 9.[1]

Oxy-hæmoglobin.—Oxy-hæmoglobin behaves as a very weak acid, and occurs to the extent of 86.78 to 94.30% in any human red corpuscles. It is formed very readily whenever hæmoglobin comes in contact with the oxygen or atmospheric air. Oxy-hæmoglobin is a very weak chemical compound, and is slightly less soluble than hæmoglobin; its

*See plate facing page 253.

spectrum shows in the yellow and the green two dark absorption bands.[1] It occurs in the blood vessels circulating in arteries and capillaries, as can be shown by the spectroscopic examination of the ear of a rabbit, of the prepuce and the web of the fingers.[2]

Spectrum of Oxy-Hæmoglobin.—In the spectrum of a dilute solution of hæmoglobin crystals of arterial blood, part of the red and violet frequencies are absorbed, but two well-marked absorption bands exist between D and E. The line nearest D, i.e., next the red end of the spectrum, sometimes designated by the letter a, is narrow, sharply defined, and black at its centre, and in its wave length corresponds to wave length 579.

The other absorption band near E, conveniently designated by b, is broader, not so dark, and its edges are less sharply defined. Its centre corresponds to wave length 553.8.

In very dilute solutions the band is the only one visible. In strong solutions the two bands fuse, but are again made visible as two on dilution of the blood.

The spectrum, therefore, necessarily varies with the strength of the solution. With a 1% solution all the spectrum disappears with the exception of the extreme red, and as the dilution continues, the orange, green, blue, indigo and violet are successively seen. With 65% solution of HbO_2 there is only one absorption band.

Spectrum of Reduced Hæmoglobin.—By adding to a solution of hæmoglobin reducing substances—e.g., ammonium sulphide, iron filings, Stokes's fluid (tartaric acid, iron protosulphate, and excess of ammonia)—the two absorption bands of the spectrum disappear, and reduced hæmoglobin (gas free) with one absorption band is formed. The color changes from a bright red to a purplish or claret tint. The two bands are reproduced by shaking the reduced hæmoglobin with air, whereby HbO_2 is again formed. So-

[1]Landois and Stirling, p. 26.
[2]Ibid.

lutions of oxy-hæmoglobin are readily distinguished by their scarlet color from the purplish tint of reduced hæmoglobin.

According to Hermann, the absorption band of Hb is not a single band, there being in addition a very narrow band toward the red end of the spectrum, but separate from the chief absorption band by a small interval.

Methæmoglobin is a more stable crystalline compound than oxy-hæmoglobin. It contains the same amount of O as HbO_2, but in a different chemical union, while the O is more firmly united with it. It shows four absorption bands like hæmatin in acid solution of which that between C and D is distinct; the second is very indistinct, while the third and fourth readily fuse, so that these last two bands are only seen with good apparatus.[1]

Freund undertook to determine to what extent the more refrangible rays were absorbed by the blood. To this end a few drops of blood from a finger tip were squeezed on to a quartz film, which was surrounded by a rim of paper 0.17 mm. wide, and covered with another quartz film. The blood completely filled this space of 0.17 mm. This layer showed a uniformly red color without any light space. Upon examination with a little pocket spectroscope, the usual absorption spectrum of blood was seen, with the characteristic absorption band between the Fraunhofer lines—D and E in the greenish yellow. By the aid of a small glass spectroscope and using sunlight, the spectrum was photographed. With an exposure of 5 minutes, the image of what had been seen was reproduced showing that absorption began at F $\frac{1}{2}$ G, and from that point onward, in the direction of the ultra-violet, practically no action on the photographic plate was discernible.

A further experiment was made in order to discover the behavior of living fresh epidermis, beneath which the blood is circulating. A frog was put under curari, then two toes of a hind foot were fastened with pegs along the edges of

[1]Landois and Stirling.

a triangular hole cut in a sheet of cork, in such a manner that the web of the foot was fixed in front of the opening of the slit of the spectroscope through which solar light was allowed to fall. The opening was 0.15 mm., the exposure, 5 minutes. Under these conditions the line H (λ 3,964 Å) was absorbed. It is interesting to know that so many of the frequencies from the more refrangible part of the spectrum should still be able to pass through when the thickness of the membrane and the quantity of the blood contained in it is considered. It follows, therefore, that a considerable portion of the ultra-violet frequencies emitted by various sources of light pierce the epidermis, and are able to reach the lower layers of the skin. So far as is at present known Freund finds that these penetrant frequencies of the ultra-violet spectrum, roughly speaking constitute a third part of the ultra-violet spectrum as at present known. There are several different factors governing these results, the intensity of the source of light, the duration of the action, and the thickness of the exposed layer. Under more suitable conditions, such as obtain, for example, in the treatment of lupus patches and nodules by Finsen's method, a more profound penetration of the epidermis by these very short and high frequencies is possible.

It is, therefore, evident that blood absorbs light to a very great extent, and in a somewhat peculiar manner. This is shown by the characteristic absorption spectra of greenish yellow obtained by Hoppe Seyler, and in blue violet by d'Arsonval. It is further emphasized by the experiments of Freund made to determine the degree of penetration of the ultra-violet frequencies. The classic experiments of Finsen evidence additionally the absorptive power of the blood for blue violet light energy. He placed a piece of sensitized (aristo) paper back of the lobe of his wife's ear. The concentrated beam of light from one of his arcs was then directed upon it, securing the passage of the more chemically active frequencies, or the blue-violet and ultra-violet. Nothing was done in the first experiment to

cut off the circulation. After an exposure of 5 minutes there was no action whatever upon the paper, i.e., it was not blackened. Upon compressing the ear between 2 glass plates until it appeared pale and bloodless, a second exposure was made for 20 seconds, resulting in a blackening of the paper. This demonstrates very clearly the fact that the blood to a very considerable extent prevents the penetration of the chemically active frequencies into the tissues, while the absorption spectrum of oxy-hæmoglobin indicates that the blood absorbs them. From the constitution and the absorption spectrum of oxy-hæmoglobin it is clear that the hæmoglobin is an active absorbent of light energy. It has been pointed out that the absorption spectrum of oxy-hæmoglobin is different from that of methæmoglobin.

It has been shown by Quincke[1] that hæmoglobin gives off its oxygen more quickly in the light than in the dark. In darkness the oxy-hæmoglobin band in the spectrum vanishes. This proves that light energy increases the oxidizing power of the blood, and proportionately the processes of oxidation in the living organism.

Absorption of light (see chapter on Fluorescence) is connected with phosphorescence and fluorescence. Fluorescent bodies exhibit corresponding absorption-spectra, and, as they absorb the ultra-violet frequencies more or less completely, they all fluoresce in this region of the spectrum.

The blood and the lymph serum are fluorescent bodies, and as such are amenable to the same physical laws as other fluorescent substances. Their fluorescent property indicates the absorption by them of the higher and more refrangible frequencies blue, indigo, violet, and ultra-violet. Spectroscopic analysis of rays emitted by fluorescent substances has shown that in them the blue and all frequencies above it are suppressed. Therefore the light so filtered ceases to excite fluorescence in any other substances exhibiting the same properties.

[1]Pflüger's Archives, 1894, Vol. LVII., p. 134.

The question of the frequencies which excite the normal fluorescence of the blood, or for that matter, any tissue of the living organism which is naturally fluorescent, is settled by this physical law. It is further substantiated by experimental data which show conclusively that these penetrant chemical frequencies are the frequencies which are absorbed by the blood.

The action of the light energy then, especially the penetrant frequencies effective chemically upon the blood, is very clear of comprehension. In the ability of the blood and other tissues of the living organism to function as a transformer under the influence of the more intensely chemical frequencies or rays of the greatest refrangibility of light is to be found the rationale of its action, both in health and in disease. There is doubtless an equally scientific explanation of the action of the frequencies below the blue, but it yet remains to be made. One thing seems certain that light produced within the body by means of drugs having fluorescent properties cannot, according to physical laws, have any effect upon the blood or other naturally fluorescent tissues of the body, if the frequency so produced is of lower order than the blue.

In discussing the action on bacteria and therapy of fluorescent substances under the action of light, it is pointed out that the results obtained by exposure of fluorescent substances in solutions, or when applied to superficial surfaces, eosin, for example, to light energy of high frequency, ultra-violet, the effect produced is due to the act of fluorescent stimulation, just as it is with chlorophyll. This stimulation when once established is a continuing factor both in normal and a wide range of abnormal conditions, and the stimulation imparted to the blood by the action of light under physiological conditions is the same. It lasts for varying periods of time within physiological limits, but the maintenance of normal fluorescent properties of blood and fluorescent tissues must depend upon (1) frequent renewals of the stimulation by exposure of the body in part or

altogether to the action of sunlight, and (2) upon the absence of pathological conditions which interfere with the ability of the normal fluorescent tissues of the body to function as transformers of the frequencies from the blue on up into the ultra-violet region. The plasmodium malaria is a notable instance of a parasite which destroys the normal condition of fluorescence.

But it does not seem unreasonable to believe that in a modification of the blood, such as is induced by the presence of a parasite as in malaria, of a toxin or poison as in syphilis or sepsis, of a bacillus as in tuberculosis, or as the impoverishment of anæmia both the rate and volume of atomic motion must be altered. There may be a great deficiency in oxygen, iron, in the saline constituents, sodium, potassium, ammonium, and calcium, which must mean an inability on the part of the blood to fix the energy transmitted to it, that is, to absorb energy of radiation at the degree which permits the fluorescent condition normal to it under physiological conditions. When the departure from the normal is not too great, in the conditions mentioned, an expenditure of light energy if sufficiently localized and concentrated, as in a cabinet for general conditions, and by strict localization and compression in special lesions, should result in physiological fluorescent stimulation. This stimulation to the oscillating swing of the atoms cannot fail of response.

Red blood corpuscles are diminished in size by septic fever, inanition, morphia, increased bodily temperature and CO_2, but they are increased by O, by cold, quinine, etc. They are also diminished, at most one-half, by hemorrhages and also undergo a physiological diminution as a result of menstruation. Under ordinary physiological conditions this is a moderate loss and they are replaced within 28 days. When the loss is excessive the period of replacement may extend over 5 weeks with the result of lowering all the vital processes, as in menorrhagias and metrorrhagias. This diminution of red blood corpuscles, with lowering of the vital processes, is more or less continuous.

The size of the red blood corpuscle is also diminished in acute fevers. In certain forms of anæmia there has been found (Hayem) considerable variation in the size of the red blood corpuscles; in chronic anæmias the mean diameter of the corpuscle is always less than normal. There is moreover a persistent alteration in the volume, coloring power and consistence of the corpuscles, consequently a want of accord between the number of the corpuscles and their coloring power, i.e., the amount of hæmoglobin which they contain. In pernicious anæmia, in which the continued decrease in the red blood corpuscles may ultimately produce death, there is a severe affection of the blood-forming apparatus.[1] The corpuscles assume many abnormal and bizarre forms, often being oval or tailed, irregularly shaped and sometimes very pale; while numerous cells containing blood corpuscles are found in the marrow of the bone. In this disease, although the red blood corpuscles are diminished in number, some may be larger and contain more hæmoglobin than normal corpuscles. In chronic poisoning by lead or miasmata and also by the poison of syphilis, the red corpuscles are likewise diminished.

The size of the red blood corpuscle also varies in health and disease and dwarf corpuscles or *microcytes* are regarded as young forms and occur plentifully in all forms of anæmia. On the other hand "giant" blood corpuscles or *macrocytes* are constant in pernicious anæmia, and sometimes in leukæmia, chlorosis and liver cirrhosis. They also appear in abnormal forms after severe burns while a disintegration of the corpuscle has been observed in various diseases, as in severe malarial fevers.

These physiological facts concerning (1) the normal condition and function of the red blood corpuscle as the oxygen storer of the blood, and (2) its condition in disease, when taken in connection with the physical effects and physiological action of light serve to illuminate the intimate

[1] Landois and Stirling.

relationship between animal life and radiant energy and to emphasize not only the fact that continued existence is dependent upon it but the physical reasons for the same.

Light Energy in Relation to the Menstrual Function and Bearing upon the Blood-Forming Process.—According to Eulenburg it is a fact that women of the far north are very much more predisposed to amenorrhœa and during the long winter night menstruation is even completely suppressed,[1] while according to Holmgren and Gyllenkreutz[2] the oxyhæmoglobin band in the blood of these subjects showed signs of extension at the close of the long Arctic night.

Light Energy in Relation to Metabolism.—In our study of the action of light energy upon animal organisms it was found that after an initial decline there was an increase in weight of the animals exposed to light as against those kept in darkness and that also tissue change went on more rapidly under the influence of light. This action may be explained by a stimulation of the nervous system, which in its reaction stimulates other vital functions, or it may be a direct action upon the blood stream itself. Of the fact that certain modifications in the tissue change in both men and animals take place under the influence of light energy, there is no question. This action must be twofold, i.e., upon the blood directly and indirectly through the nerve system.

There are certain observations based upon experimental work which seem to favor the theory of a stimulating action upon the nervous system. Quincke[3] demonstrated by his experiments that various tissue cells, pus, blood, muscle, kidneys, liver, etc., absorbed more oxygen in the light than in the dark. So long as they are not quite dead severed muscles and nerves according to Moleschott and Fubini[4] eliminate carbonic acid more freely in the light than in the dark.

That light energy influences the oxidation of the tissues

[1]Quoted from Strebel, Die Verwendung des Lichtes in der Therapie, p. 8.
[2]Quoted from Gebhard and Moeller by Freund.
[3]Pflüger's Archives, 1894, Vol. LVII., p. 134.
[4]Quoted by Freund.

is the consensus of opinion and the author believes that this is largely due to a direct action upon the blood itself. Ultra-violet and blue-violet frequencies are absorbed by the blood better than by any other tissue. Physically it seems quite possible that the ultra-violet frequencies are in step or tune, so to speak, with the vibrational activity of the oxygen atom, in other words that there is a sympathetic resonance between them.

The observations of many experimenters on many different occasions tend to show that on both men and animals light energy has an influence tending to increase the oxygenating power of the blood and the oxidation of the tissues. Moleschott,[1] Selmi and Piacentini[2] found that dogs, hens, pigeons and frogs eleminated less carbonic acid in the dark than in the light. According to Moleschott, the amount of the carbonic acid eliminated is in direct ratio to the intensity of the light. Still further it has been observed that with frogs and toads the blue frequencies of the spectrum are most effective in increasing the amount of carbonic acid given off, while with birds and rodents, the red frequencies had the most influence. This was observed by Pott.[3] Van Pech[3] found that beetles (Brunchus Pisi) consume more oxygen in light than in the dark. Scharling,[3] Pettenkofer and Voit,[3] also Fubini and Ronchi,[3] have proved that human beings give off less carbonic acid in the night hours than in the day, even with absolute rest in the last instance. Fubini and Ronchi confined their researches to a single limb, forearm and hand.

As against these observed facts are the statements of Brown-Sequard, Pflüger and others,[3] who believe the increased elimination of carbonic acid is very apparent and occasioned by the movement and enlargement of the muscle under the influence of light energy.

[1]Wiener Med. Wochenschrift, 1885, No. 43.
[2]Rendi conti del Reale Instituto Lombard di Sc. E. lettre, 1870, Vol. III., Ser. II., p. 51, ref. Allg. Med. Centr. Ztg., 1872, p. 810.
[3]Quoted by Freund.

It was found by S. Goodnew[1] that persons and animals to whom daylight was accessible excreted more urine, urea and chlorides than those who stayed long in the dark. This is substantiated in the author's clinical experience.

It has been proven by Moleschott, Bechard, Selmi and Piacentini, Pott, Pflüger and von Platten[2] that under the influence of light, through stimulation of the retina, marked elimination of carbonic acid and consumption of oxygen took place.

There is also observed from experiments upon animals which have been deprived not only of eyes but even of brain and lungs as well, that tissue change may be influenced by reflex action through the skin. Certain of these points as to increased elimination of carbonic acid and tissue change under the influence of light energy have been refuted, but the burden of experimental evidence as well as clinical fact is in favor of an influence upon the former tending to its increased elimination, therefore increased consumption of oxygen and consequent action upon metabolism.

According to the observations of Graffenberger[3] and others among them, Bidder and Schmidt, the metabolism of carbon compounds is lessened in the dark, and more fat is formed and deposited. Animals kept in the dark, geese, for example, while being fattened, increase in weight. As tissue change goes on more rapidly under the influence of light energy this is what should be expected, viz., a retardation of metabolism. Because of this fact starving animals, men even who are deprived of food by the exigencies of life, exist longer if they may remain quiet in the dark. In the absence of normal metabolic change, the reserve nutrient supply is not consumed so rapidly as in light. Fat is a product of imperfect oxidation. This physiological fact taken in connection with the preceding observed facts as to

[1]Zur Lehre v. d. Einfluss d. Sonnenlichtes auf die Thiere. Kasan'sche Dissert., 1882.
[2]Archives f. d. ges. Physiol., 1875, XI., pp. 263, 272.
[3]Pflüger's Archives, 1892, Vol. LIII.

the relation of light to tissue change is of utmost importance in its practical application in the treatment of all conditions of imperfect tissue change or metabolism and by no means least of all, its rational use in the treatment of obesity, whether primary or secondary to some disease.

According to Justus Gaule[1] the fatty bodies lying next to the sexual organs in frogs disappear in winter time during the day and are formed again at night. This was observed with blinded frogs as well, showing that the light energy upon the fatty bodies takes place through the skin.

The Influence of Light upon Metabolism.—That there is such an influence is demonstrated by the abundant proof provided in:

(1) The influence of light energy upon the blood itself and the entire circulation.

(2) The influence of light energy upon the tissue elements.

(3) The influence of light energy, i.e., its stimulating effect upon the nervous system, producing increased action of the muscles (Pansini), and movements of the body (Loeb).

(4) The influence of light energy upon the organs of sense, stimulation of the visual organs, thereby increasing directly or reflexly the energy of the functions of the body.

The Influence of the Different Frequencies of the Spectrum upon Assimilation and Disassimilation.—This subject was investigated experimentally by S. Daistch[2] and B. Kogan,[3] who formulated the following conclusions:

(1) Red light weakens the processes of both assimilation and disassimilation; (2) green light stands lower than white, in regard to the accumulation of nitrogen, as well as to qualitative metamorphoses; destructive changes proceed

[1]Centralbl. f. Physiol., 1900, Vol. XIV, p. 25.
[2]Ueber den Einfluss des weissen Lichtes und der verschiedenfarbigen Strahlen auf den Gasaustausch bei Warmblütern. Petersburger Dissert., 1891.
[3]Ueber den Einfluss des weissen (electrischen) Lichtes u. der verschiedenfarbigen Strahlen auf die Stückstoffmetamorphose bei Thieren. Petersburger Dissert., 1894.

more vigorously in green light; (3) yellow and violet light induce the maximum of energy in all the vital processes, more complete metamorphoses prevailing under the influence of violet light; (4) darkness causes a diminution in the exchange of nitrogen in the body and incidentally, diminution in the daily amount of urine.

The Influence of Light Energy upon the Respiration, Pulse, and Temperature.—In clinical work the author has observed an influence upon these functions from exposure of the entire nude body to light energy. For example, in a given case 13 observations of the pulse and temperature were taken, in 11 instances the pulse dropped while its volume was improved in every instance. In each of the 13 observations there was a rise of temperature, ranging from .1 to .8 of a degree. The exposure was made to the energy of a 15-ampère electric arc. This influence has been demonstrated clinically in a large number of instances.

Observations have been made experimentally as to the influence of light upon respiration, pulse and temperature. Féré[1] found in one case that respiration was 19 to the minute in yellow light, 17 in green, and only 15 in red. Under the influence of red light the pulse becomes fuller and slower; in darkness it falls so greatly that the sphygmograph ceases to show oscillation. It was also observed by Goodnew[2] that the number of heart beats and the rate of breathing increased noticeably, while the animals upon which he was experimenting were under the influence of the light.

Under the guidance of W. von Bechterew, Trivus[3] studied the influence of colored light on the pulse of healthy persons. Mosso's plethysmograph was used in the experiments. The subjects were kept as a rule for two hours in a special colored room of the clinical hospital. The plethysmograms were taken at the beginning and at the end of each

[1]Dégénéresence et Criminalité, 1888, quoted in Raum.
[2]Loc. cit.
[3]Quoted in Dworetzky and by Freund.

experiment. In most cases colored light was found to depress the pulse, that is, it became less rapid and full. This depressing action was most marked in the violet, least in the red. The action of the other colors correspond with their places in the spectrum, yellow excepted. This had no effect at all, probably because it permitted the passage of all the frequencies above it. It was surmised by Trivus that as every colored light ray formed in itself only one part of the energy of the complex of all the frequencies, or white light, necessary for physiological nerve tone, that colored light must be regarded as a form of light hunger, which produces a certain minus in the chemistry of the animal body. In other words, the effect of any one color may be explained not by its own action, but by the absence of the action of all the rest of the spectrum.

According to Raum, light energy exercises an influence upon the daily fluctuations of temperature conversion of matter and excretion in human organisms, both healthy and sick. It is not only pulse, respiration and temperature which are affected by light baths, but there is secured better functioning of all the organs, with relief from the varied manifestations of impaired function. This influence has extended itself even to habitual constipation.

In the weakening influence of red light upon the process of assimilation and disassimilation is to be found a rational and satisfactory explanation of the intense nerve and mental excitement of workmen compelled to labor in red-lighted photographic rooms, and in the excitement and delirium of smallpox patients.

Nothing exercises a more untoward influence on the nervous system than imperfect metabolic change. The mental excitement, delirium, etc., could be accounted for (1) by the deficient nutrition which would result in consequence of weakened assimilation, and (2) by the toxic effect of the products of imperfect disassimilative processes. On the other hand the stimulating effect of red light may, and probably is, in part, at least due to an action

upon the nerve centres, and from the evidence the author is disposed to believe that it acts primarily upon the sensory cortex, and that the depression of the melancholiac is overcome through the sensory centres.

The Influence of Light Energy upon the Nervous System.

Introduction.—It has been pointed out from time to time, both in discussing the physics of light and the rationale of its action therapeutically, that chemical action pertains to every frequency of the spectrum, to those of long wave length, and low frequency as well as to those of short wave length and high frequency, and that they were respectively active according to the object upon which they fall. The frequencies are, therefore, thermal, luminous or chemical, according to the nature of the body upon which they fall.

When light which falls upon a body is absorbed by it, one of the three following results will follow: (1) chemical, (2) thermal, (3) electrical.

In the first instance, as in the action of light upon the blood and living tissues, the result produced by the chemical action is one of conversion by oxidation; in the second there will be no chemical change, but the energy will be converted into heat. This will be shown in absorption phenomena in the case of substances colored with pure spectrum color; in the third the action of the light energy may give rise to electrical phenomena in two ways, by setting up electric currents, and by increasing electric conductivity of insulated substances. In common with the phenomena accompanying all manifestations of energy the course of these phenomena is seldom a simple one, but is complicated by various simultaneous processes of similar kind.

As yet the physiology of light energy as it relates to the living organism is not sufficiently exact to enable us to say just what is the action of all of the different frequencies.

Of this we are certain, viz., that it is the short and high frequencies which chiefly affect most bodies.

In the living organism different tissues and different fluids are differently affected by light, as is evidenced by their various absorption spectra. Blood corpuscles and albuminous substances give different absorption spectra. The energy of radiation is absorbed by the blood corpuscles at different degrees or wave lengths. Certain of the long and slow frequencies are absorbed, also the short and high frequencies of the blue and ultra-violet. Albuminous substances, however, absorb the short high frequencies almost exclusively.

From a study of the absorption spectra of animal organic substances as well as the physiological effects upon the organism, their ability to react readily to the influence of light is clearly evidenced.

The Action of Light Energy in Producing Motor Excitation.—Exposure to the action of light gives rise physiologically to movements by reflex as well as by direct action on the tissues of animals. Upon exposure of the eye to the energy of the green region of the spectrum, Dogel and Jegorow[1] found that the circulation of the blood both in men and in dogs was very markedly changed by the irritation.

P. Bert[2] found that a chameleon, blinded in one eye became paler in color on the whole corresponding side of the body. That the color of the skin is acted upon reflexly by light energy is also proved in other animals, the octopus, for example. A reflex action by means of the skin and eye thus affects the change of matter.

The Action of Light Energy in Stimulating Other Nervous Organs.—It is a recognized physiological fact that sudden exposure to bright light will excite violet sneezing.[3]

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[1]Quoted from Dworetzky's Ref. Zeitschrift f. diät. u. Physik., Ther., Vol. V., p. 165, by Freund.
[2]Quoted by Freund.
[3]Landois and Stirling—Text-book Human Physiology.

This phenomenon is without doubt due to an action upon the sensory fibers of the trigeminus distributed to the conjunctiva. If the eyes are tightly closed, despite the fact that the red frequencies filter through the translucent eyelid, the disposition to sneeze disappears. This shows that it is the chemical energy of light which acts as an irritant, for upon opening the eyes, the inclination to sneeze is felt at once, which is followed by actual sneezing. The secretion of tears may also be excited reflexly by strong stimulation of the retina by light. This comes through a stimulation of the first and second branches of the trigeminus, and through all the sensory cranial nerves (Demtschenko).[1]

The Influence of Colored Light upon the Nervous System.—It has long been a matter of common observation that different colors produce definite effects upon the senses and feelings. And it is also evident from many biological facts that light has a powerful influence upon the nervous system and the organs of sense.

Red is always spoken of as a warm color, blue as a cold color, yellow as a cheerful color, green as a restful color, etc. There is a difference in the way that different people are affected by color; one is pleasantly impressed by a certain color, another is the reverse. This indicates a reflex effect upon the nerves. Some are in tune with certain frequencies, others with certain other frequencies, pointing to an inherent difference in constitution, so to speak. The effect of light energy is not only seen in the action upon the nervous organs, but upon the mental state as well. There are also many phenomena and modifications of vital functions which arise from its indirect action.

In the "Undecaying radiance of the sun man takes great delight." There is no natural phenomenon which produces so profound an effect upon the mind of man and his consciousness as light.

"The royal sun feedeth all," but it is not only physical food but mental as well. Under the transition from darkness to light the stimulation of the mental power is greater than from any other form of energy. The withdrawal of this stimulus or reversion to darkness has the opposite effect.

[1]Landois and Stirling: Text-book Human Physiology.

Buedingen[1] from his experiments concluded that the reflex irritability of the spinal cord is not influenced by light rays falling on the skin. These experiments were made to solve the question whether light acts directly on muscle or through the motor nerves, when applied to the nerve muscle preparation. These experiments show that light as applied in the form of sudden transition from darkness to a blue or red light in concentrated form had no direct influence on nerve-muscle preparations made from frogs and further that it was not able to modify contractions caused by their stimuli.

He also made experiments with animals whose cerebri had been removed and in whom the nerve connection between brain and spinal cord had been severed to determine whether reflex movements can be established by the action of light energy upon the skin. From exposure to the concentrated energy of the blue and also of the red frequencies of the arc light spectrum, not the slightest trace of reflex irritability was observed. The experiments of Finsen show that ultra-violet rays act as a vigorous irritant to the nerve system and that by them skin reflexes are increased. From the nature of their action upon the skin (chemical) such an increase of the activity of skin reflexes and irritation of the nerve system would rationally follow.

Schmidt, Rampler, and Ponct are quoted as authorities for the statement that psychical disturbances even to actual delirium have been observed in the eye hospitals where patients have been forced to live for a long time in the dark. Cases of different psychoses, following operations upon the eyes, are recorded by Frankt-Hochwart, Landersberg and Elschning.[2] Numerous experiments were made by the phy-

[1]Zeitschrift diät. und Physik. Therapie, Vol. VI., bk. 5, p. 272.
[2]Quoted by Pansini.

siologist de Parville[1] with the different parts of the spectrum. These experiments, referred to constantly in the literature of photobiology, convincingly show that the red frequencies act as excitants to the nerves. The recent experiments of Pansini point in the same direction. De Parville's experiments demonstrated a calming effect from the other end of the spectrum, attributed to the green, blue and violet frequencies. Another physiologist[2] has produced sensations of faintness by exposure to red light and afterward the symptoms have been removed by exposure to the conjoined red and green frequencies.

In a large photographic plate manufactory, it was noted that a change of color in the light of the workroom from red to green acted to materially modify the excitability of the workmen. They were singularly lively over their work, singing, arguing loudly and gesticulating vehemently. They became much quieter after the change.

Goethe in his "Farbenlehre" or in his "Theory of Colors"[3] called attention to the connection between colors and certain emotions. He observed that red and yellow light energy exercised a bracing effect, while green and blue were depressing. The observations of Baron Reichenbach[4] were to the same effect.

Akopenko,[5] who worked in the laboratory of Bechtrew, proved that the duration of psychical processes is unquestionably affected by the energy of the different parts of the spectrum. A more invigorating and stimulating effect is noted from the effects of the colors nearest to the heat rays. The mood of the person under observation is affected; in red light he feels brisk and cheerful, inclined to move and

[1]J. P. T., Dec. 15, 1900. Taken from Pharmaceutical Journal, no date given.
[2]Journal of Phys. Ther., Dec. 15, 1900.
[3]The student will find Tyndall's ("New Fragments") analysis of this work of Goethe, of interest, showing the misapplication of physical principles by that author but his richness in facts.
[4]Quoted by Freund.
[5]Quoted from Dworetzky's Refer. Zeitschr. f. diät. u. phys. Th., Vol. V., p. 165, by Freund.

act. Physical effects are noted; for example, at the close of the sitting headache has sometimes disappeared. Yellow light comports itself like daylight. It has no special effect on the quickness of physical reaction nor on the temperament. The shorter and higher frequencies from the green up have a depressing effect. A prolonged sojourn in a room with green light, which at first is pleasant, becomes later on very oppressive. Psychical processes are retarded under its influence, mental quietude results, movement is checked and excitement allayed. The effect of violet light is still more depressing. The mental attitude becomes dreamy, even melancholy; after some time headache is experienced. The psychical processes become very slow and are checked, while the feeling of general depression becomes almost unendurable.

The Influence of the Red and Blue Frequencies of Light upon the Excitability of the Cerebral Cortex.

Introduction.—The recent experiments of Raffaele Pansini[1] upon the electric excitability of the cerebral cortex under the influence of light are confirmatory of de Parville's experiments as well as of a considerable amount of biological and clinical observation.

Pansini calls attention to the expression of sadness acquired by those who are blind. There is a sobriety as well as sadness of mien, in contradistinction to the joyousness of mood and alertness of mind, experienced under the influence of the radiant energies of the sun. There is no question as to the influence of sunlight upon the spirit of the individual. Pansini speaks of the cerebral excitation and mental disquietude referred to on a preceding page, produced in those forced to carry on their avocations in a room with red glass in the windows, so extreme that it was necessary to

[1]Recherches Experimentale Sur L'Excitabilité Électrique de l'écorce Cérébrale par la Lumière Rouge et La Lumière Bleue, by Raffaele Pansini. Revue Internationale d'Électrothérapie et de Radiothérapie, Nov. 1903.

replace the red glass by glass of green coloring. According to the same writer, Courmand reports 4 instances of psychic hyper-excitation in patients with smallpox, who were in a red room. So great was their mental distress that they begged to be taken into the light.

Olenikoff noticed the same condition in smallpox patients of the clinic of Tschistovitsch, who were submitted to the red light treatment. They suffered from delirium with frightful hallucinations, which at once passed away upon their being carried into a light room. In this same connection Pansini called attention to the state of fury or excitement induced in the bull by objects with red coloring. These facts have led to the conclusion that the frequencies of the red region are to be regarded as a dynamic agent, and an excitant to the nervous system in general, but especially to the psychic functions. This view is endorsed by Binet, Féré and Gilles de la Tourette.[1]

According to them the nerves are also strengthened by the energy from the red region.

Pansini's Experiments.—By his experiments conducted at the Institute of Physiology of the Royal University of Naples, R. Pansini has attempted an elucidation of the problem. He endeavored to study the modification of electrical excitability under the influence of (1) blue light, (2) red light. To this end dogs were selected and trepanned in order that the motor area or sigmoid convolution of the cerebral cortex could be exposed to the action of the light. The electrical tests were made both before and after exposure to the different light energies. Pansini does not regard the number of his experiments as sufficient from which to draw definite conclusions, but presents in his report the more important effects noted. The greatest care was taken in the technical management of his work to prevent any error which might have falsified the result of his researches. Very feeble currents were employed at not too frequent intervals, and an

[1]L'Année Électrique, 1901, p. 368.

equal pressure of contact in the different tests applied. In addition a long period of repose was permitted each time that the animals presented an approach to an epileptiform convulsion from the stimulating action of the magneto induced (*"electro-faradic"*) current. Care was also taken not to permit the slightest elevation of temperature in the tissues influenced by the colored lamps, while the normal excitability was carefully guarded. Pansini in estimating the results obtained considered (1) the diverse intensity of the reaction established by the electric stimulant; and (2) the diverse intensity of the stimulant necessary to provoke reactions in the muscular group stimulated. His results in the latter respect were negative, and in a degree contradictory. Twice in 30 observations he had to apply the secondary of a Du Bois Reymond coil to provoke reactions after the influence of the blue light. Two proofs out of 10 he regards as insufficient for formulating the conclusion that blue light renders necessary a greater stimulation to excite the cortex in the same manner, nor was he sure that the reactions were produced from the action of the red light. There was but one instance following the use of the red light, where the reaction extended to 2 centimetres of the secondary; in all the other researches it never reached anything like it. The contrary effect is sometimes produced, rendering it necessary to apply the secondary after the action of the red light, to secure reactions, especially when bandaging the eyes of the animals. From this single instance the conclusion that red light exaggerates the electric excitability of the cortex is at once impossible and unscientific. From exposures to blue light it was found that although the depressing action upon the excitability of the cortex was wanting in part and in others absent entirely, that in the great majority of the observations made, it reduced the reactions of the same brain to a minimum, and that the same brain, both in normal conditions and after exposure to red light, gave epileptiform reactions. Pending the use of the blue light, these reactions were constantly reduced to some simple muscular jerks.

Despite the many possible sources of error, both in valuation and interpretation of the phenomena encountered, the results noted cannot be doubted. The conclusion as to the depressing action of the blue light upon the motor area of the cortex, is not based upon any elastic differences such as the differences between a muscular shock more or less energetic, more or less prolonged, but upon the important phenomena of tetanus and epileptiform attacks. These are absent after the use of the blue light, although present before its use under ordinary conditions and recurring after exposure to the action of red light. Blue light, therefore, Pansini affirms, has the property of reducing to a minimum the reactions of the cortex and also prevents the action of the stimulus which is exercised upon it at one point, from extending to the other motor areas. This, Pansini concludes, seems but rational when the analgesic action of light is considered, and its power to annul sensibility to touch and pain, as shown by his own experiments. Physiologically, it is known that all anæsthetic agents, morphine, ether or chloroform, for example, when applied to the cortex diminish or suppress entirely the excitability of that part. The blue light is thought to act in the same fashion, and from this point of view he regards the effects observed as perfectly explicable. The electric (magneto-induced) excitability is not completely abolished in the majority of instances, therefore it cannot be regarded as establishing a true anæsthesia.

In conditions of mania where it might be supposed that physiological stimulation would increase the excitability of the cortex, the action of blue light seems to produce a transient calm. Because of the great penetration of these frequencies, the brain is undoubtedly affected even through the cranial case (Dobrjansky). Even so the author thinks it entirely within the bounds of physiological action that the action of the chemical frequencies of light upon the peripheral circulation of the overlying tissues of the cranium, may affect the deeper circulation of the brain itself, and that

this may result, so to speak, in securing an unloading of congested areas, or a return to more nearly normal conditions. This is what happens from the action of light on an inflamed joint, for example, not a light thermally active, but a cold light, and the one is to a degree just as reasonable as the other.

When the eyes of the animals experimented upon were carefully bandaged, so as to exclude any possible effect upon the visual organs, there were no modifications whatever in the effects produced by the action of the blue light, which simply substantiates the theory, that the results obtained are due to the penetration of the chemical frequencies and their action on the circulation. This action by reason of anatomical conditions can only be limited in comparison with the action obtained in deep-seated skin lesions. The action of red light seems not so clearly proven, as in the majority of instances, Pansini found that it gave the same reaction as in ordinary conditions. Twice only, when nonexistent before, were epileptic convulsions produced under its influence. In numerous other instances, however, much more energetic and more prolonged reactions (so to speak) were produced under its influence, but of exactly the same nature as under ordinary conditions.

Throwing out of consideration the experiments which are of questionable value, there remained but 2 positive proofs of increased excitability of the cerebral cortex under the influence of red light, as against 8 negatives, which Pansini wisely concluded were too few from which to deduce a law as to increased excitability of the cerebral cortex, to electric stimulation under its influence.

It is suggested that the action of red light is not a direct one, but that it is best explained by the way of the visual organs. This theory is in accord with Bellini's observations, and also with a very great deal of clinical observation. Whenever the eyes were bandaged, Pansini found that a much more intense stimulation was required to provoke reaction than was true when they were exposed to the action

of light. One deduction only can be made at this time, from the experimental work done, viz., that red and blue light frankly exert directly opposite effects upon the excitability of the cerebral cortex. Further experimental observations are to be made by Pansini, to more fully elucidate this interesting problem.

In extreme conditions of nerve exhaustion associated with a very considerable anæmia, the author has observed a very great desire on the part of patients to have red fabrics almost exclusively for articles of dress. This was very marked in a woman physician, who had exhausted the supreme nerve centres, motor, vaso-motor, sensory and intellectual, and who was also profoundly anæmic. During several years of ill health her dress, cloaks and hats were almost exclusively red. There was an intense craving for the color, and none other seemed to satisfy the need, while black, which she had been in the habit of wearing before her illness, produced a feeling of profound depression. With lessened anæmia and an increase of nerve energy, the desire for red fabrics grew less, while with further improvement, characterized by still greater nerve force and disappearance of anæmia, she no longer cares to wear it. But whereas formerly the brain was profoundly anæmic, and the supreme centres well-nigh exhausted, there has superseded a condition of more or less cerebral congestion, aggravated by over-anxiety or application. Since this condition was established there is an aversion to the wearing of red fabrics and red generally because they produce a sensation of distress and discomfort in the cerebrum. This patient had earlier in life suffered from insolation. Her observations are worthy of attention as she approached an analysis of the matter with a specially trained intelligence both in physics and in medicine.

Blue light on the contrary is regarded as exerting a quieting influence upon the cerebral system. In marked contrast to the feelings of joyousness and gayety induced by red light, is the sense of quiet, even sadness, aroused

by violet coloring, which is regarded as the emblem of grief.

In experiments made upon dogs by washing away the cortex cerebri, Goltz[1] found that after a sufficient amount of gray matter had been removed, and the animal had recovered from the immediate effects of the operation that there was established peculiar defects of vision and other sensory defects. There seemed to be established a condition of "psychical blindness." The animal is not blind, can see and use his eyes to avoid obstacles, for example, but seemed to fail to recognize food or flesh as such when placed before him. The following observation is of especial interest in a study of the action of the red frequencies of light upon the cerebral cortex. Goltz caused his servant to dress himself in a mummer's red colored garb, which previously had greatly excited the dog, but after the operation the animal, although not blind, was no longer excited by it. This would seem to indicate that the sensory cortex takes cognizance of these frequencies. In the neurasthenic patient referred to, who clothed herself in red almost entirely, there had been marked congestion of the sensory cortex prior to the extreme exhaustion of all centres, sensory included. There had been no injury as with a traumatism other than insolation, simply a loss of energy with diminished function. The penetration and absorption of frequencies of the red region seemed to supply a needed stimulus. The indications were for exposure to the radiant energies of the sun, but by reason of the necessities of the case and environment, as well as because of the previous insolation there was but one course to pursue, and that involved the spending of the hours other than those demanded by professional duties, very quietly indoors from one month to another. In the dog whose cerebral cortex was washed away, there seemed no response to the periods characterizing the vibrational activity of the red region of the spec-

[1] Landois and Stirling.

trum, although vision as vision was intact. This is but one of the many different phenomena which appeared from these experiments of Goltz. It is only instanced here because of a certain evidence which has been accumulated from time to time tending to show that there is some definite relation between this part of the spectrum and the stimulation of the sensory cortex.

Foveau de Courmelles reports an instance of a young man who, upon entering into a violet room, became very sad and began to weep. Insane patients have been at different times exposed to the influence of red and blue light, according to the form of mental disorder.

Ponza (quoted by Pansini) placed a melancholiac of a sombre humor, and with a "taciturn frenzy" in an all red room. After three hours spent there the patient was gay and smiling. On the other hand, a maniacal patient, forced to wear the straight jacket, by reason of his mania, became after an hour and a half spent in a blue room much more calm. Another case of mania after a day spent in a violet room felt himself cured and left the asylum in good condition. Ponza has treated hypochondriasis by red light, mania by blue, while violet light was used for depression of the nerve forces. The editor of the Inventuo Médica, in Guatemala,[1] is said to have noted the same fact 20 years previously. These experiments first made in Italy were repeated by alienists elsewhere. One of the first to do so was von Paquet in an asylum at Moscow, but his results were entirely negative. Schleger, who made a large number of observations, concluded that the blue light produced a transient calm in only a limited number of maniacal cases. This calm which follows after a short time is of short duration, is not followed by any dangerous consequences, and is proportionate to the intensity of the light.

In somnambulism, Charpignon has found violet light to exercise a quieting influence. In those suffering from

[1]Quoted by Freund.

pathological excitement, Uffelman finds that violet light exercises a quieting influence. More recently Joive has produced in the case of neurotic patients a quieting effect by the influence of violet light; while Denys, availing himself of the great penetrancy of violet light, has tried by means of it to influence the brain of the insane. The researches of Dobrjansky tended to prove their penetration even through the skull.

If it is by the penetration of the chemical frequencies that the condition of sunstroke or insolation is produced, there seems no reason why, in certain cerebral conditions involving over-excitation, there should not be sufficient penetration from exposures to blue light, suitably regulated to favorably influence the mental condition. The mode of action of these frequencies in such conditions, is at the best conjectural. From the fact that the blood and lymph serum are fluorescent bodies, and that the chemical frequencies are absorbed by them, taken in connection with the well-known action of blue light on certain substances other than those contained in the living organism, the author is led to believe that it is by reason of a direct action of the light upon the blood itself; its function as a radiant energy transformer is stimulated. This light energy unquestionably is converted into chemical energy, as is shown by increased oxidation due to an increased storage of oxygen in the red blood corpuscles. Upon the storage of oxygen in the latter, the necessary oxygen saturation of the circulating media depends. In nerve and mental conditions the rôle of toxæmia is one of paramount importance. As a theory of the action of blue light may be admissible until the facts are established, it is suggested that because of the powerful action of the chemical frequencies of light upon the blood, the systemic toxic condition which is reacting upon the supreme nerve centres is overcome through the increased oxidative power of the blood. The selective action in a series of maniacal cases suggests that the cases favorably influenced are those in which the over-excitation or maniacal condition

is purely functional, due to a toxic or an anæmic condition, and that in others not so affected, the mental condition may be due either to an organic change in the supreme nerve centre or the reflex of a morbid condition elsewhere in the body.

There is afforded sufficient foundation for both future photobiological research and clinical observation in the relation of life to light and its action in many manifestations of disease.

Bellini believes that the quieting action of the chemical frequencies of light is induced by the general revulsive effect which it exercises upon the entire superficies of the body. This is undoubtedly, in part at least, due to a direct action upon the peripheral nerve endings, and is an effect of the action of the chemical light energy upon the tissues and their absorption by the blood. The same writer suggests that the action of red light upon the brain is brought about through the eyes and their intimate connection with the brain through the optic nerve. The exciting effects of the red frequencies he believes to be due to their action as a quick stimulant. No suggestion is made as to how they act, but by reason of their long length and infrequent rate, as compared with the chemical frequencies, they have a greater degree of penetration, as is beautifully shown in the transillumination of any part or organ. Foveau de Courmelles[1] regards colored light as an actuality in the treatment of mental alienation. In 1886-87, at the Charity Hospital of Paris, J. Luys[2] showed that hypnotic subjects were sensitive to red as an excitant, and to blue as a depressant. Since 1890, Foveau de Courmelles has made observations at his clinic, showing that the waking state was affected in the same way. To the use of colored light, incandescent, in 1891, he gave the name of "Chromotherapie," the therapeutics of color.

[1]Revue Internationale d'Électrothérapie et Radiothérapie Jan., 1904.

[2]Quoted by Foveau de Courmelles.

The Influence of Light upon Muscular Structures.

The Action of Light Energy in the Stimulation of Striped Muscular Fiber.—It is not known that light has any influence on the movements of striped muscular fiber. A good deal of study and experiment has been made as to the effect of light energy on muscle.

Pansini's experiments seem to show conclusively that the action of chemical light energy increases the power to do muscular work. This would be expected from its action on the blood.

The Action of Light Energy in Stimulating Muscular Work.—Equally interesting and valuable is the work done by Pansini on the biological action of electric light upon muscular action. The results obtained by him, although working in an entirely different manner, tend in the same direction as those of Finsen, Freund, Bernard and Morgan, as well as a host of others, and are corroborative of the opinion held to-day both by the physicist and the physician that it is the chemical rays which have the power to penetrate deeply to awaken reaction in the tissues, and are, therefore, capable of establishing therapeutic effect.

According to Rieger the chemical rays produced motor excitation in the nervous system, while Parville has found that excitations of the peripheral nerves are also produced by them. Gerhard, Pflüger, Cazenave, Ratier, Furie, Fossangrève, Aubinois have all demonstrated that light has a direct action on the muscles and nerves. From baths of electric light Colombo found that the chemical radiations exert a stimulating action on all functions of the skin through the bio-chemic action which they awake in the tissues. Because of all these facts, Pansini was led to undertake a series of experiments to find out if blue light could have any biological action upon muscular work. While the fact of muscular excitation by light has been recognized these are the first experiments made to demonstrate its influence upon muscular labor.

Pansini's experiments were made at the Institute of Physiology of the Royal University, Naples,[1] in the dark chamber devoted to phototherapy and with the ergograph of Mosso. The subject chosen for all the experiments was 30 years of age, in perfect health, of normal structure of skeleton and muscles, but little used to muscular labor. Therefore the weight used in all the experiments was but one kilogram. The source of light was furnished by lamps in blue, white, and red glass of 50 candle-power each, and each was provided with a metallic reflector on a universal joint. The time was regulated by a metronome, registering 84 beats a minute. The conditions of the subject were kept the same as far as possible every day. Eight tests a day, in two series of 4 each, were made, an interval of 20 minutes being allowed for rest in the open air between the two series, and also a 5 minutes rest between every two tests. Ergographic tracings, showing exactly the amount of work done by a normal muscle unacted upon by any extraneous influence were first made. Every test made under the influence of light was also accompanied by its ergographic tracing.

As a result of these experiments it was found that (1) blue electric light exerts a favorable action upon muscular work in increasing energy and resistance; (2) that the favorable action upon muscular work is explained by the influence upon the muscles in activity which light exerts upon the muscles themselves; (3) the favorable action is not in every case proportional to the time in which the blue light has acted on the muscles. For example, muscular work is positively increased by exposure to blue light during 15 or 20 minutes, but with longer exposures (an hour) there is a rapid increase of muscular activity which speedily fails. This was beautifully shown in the tracing made after the hour's exposure. (4) The effects of blue

[1] L'Action Biologique de la Lumière Électrique, Sur le Travail Musculaire. Par le Dr. R. Pansini. Revue Internationale d'Électrothérapie et de Radiographie, October, 1903.

light upon muscular work diminish in proportion to the time elapsed since the exposure; (5) the action of blue light upon work probably corresponds to the speed of material exchange in the muscles, which are the true organs of motion, since the action of the colors of the spectrum upon nervous excitation is not yet surely proven; (6) action upon muscular work is an attribute of blue light and not that of other colors of the spectrum, since white has no influence, and red depresses rather than stimulates muscular work. Since red depresses muscular work the conclusion is forced that it has no bio-chemic effect upon the blood or muscular structure. It is dynamic and especially addressed to psychic functions.

Pansini's work is accompanied by ergograms, each test showing the effect of blue light, red light, and the absence of effect of white light. These ergograms are most graphic illustrations not only of the number of muscular contractions but of the change in amplitude as well. In the test for control the amount lifted in the first test was 1736 kilograms; in the second, when the muscles had not recovered from the fatigue of the first but 1,455 kilograms. On exposing the arm to a beam of light from the blue lamp the work done for the test with muscles already fatigued by the two tests of control, was 1,848 kilograms, an increase of 112 kilograms over the normal. These experiments have not only a value in demonstrating the power of light upon muscular labor, but are extremely suggestive as well. The depressing influence of red light upon muscular activity, taken in connection with its well-known stimulating effect upon the nervous system, points to an action of the longer slower frequencies either directly or transformed into electric currents, upon the nervous system. The depressing effect of long-continued exposure to the blue frequencies with their well-known vaso-dilatory powers can better be accounted for.

The Influence of Light Energy upon the Functions of Internal Organs.—There are modifications in the functions

of internal organs to be ascribed to both reflex and transferred action of light energy. It is maintained both by Holzknecht and Bie that this is only an indirect action. They reason that as it is the chemically active energy of light which is effective and which is completely absorbed by the organs on the surface of the body, there can be no effect other than a direct one. Holzknecht goes further and states that he regards light treatment of all internal organs as perfectly useless. He asserts that there can be no curative action exercised by light energy below the surface, that there neither is nor ever will be any kind of irradiation available for the cure of deep-seated disease, for any irradiation which is effective deep in the tissues must at the same time destroy the upper layer of the tissue. In this, the author, in common with Freund, from whom Holzknecht's statement is quoted, cannot concur. The penetrant frequencies of light energy have no such destructive action. It is the ultra-violet energy which is largely absorbed in the upper layers of the skin. True, this has a very decided action upon living tissue, but it is an action, so far as demonstrated, which is superficial. With powerful light intensity and long exposures, the penetrant chemical light frequencies, from the blue to the violet, influence favorably the deeper tissues. This is shown in their effect upon the more chronic and deep-seated lupus processes in glandular enlargements and masses of exudate for example, an effect not necessarily accompanied by any destructive action upon the skin itself.

The clinical use of light energy comprising the entire spectrum in systemic conditions, demonstrates that there is an effect due to the longer and slower frequencies. Just what it is, just what the relation between effect and degree of energy is not known, but it unquestionably exists. It is not safe to generalize from a specific action of but one-fifth of the energy of the spectrum on specific tissues, nor for that matter to reach conclusions from a generalization. The frequencies of the spectrum penetrate more and more deeply according to their place therein; the longer and

slower frequencies of the red region penetrating the more superficial tissues completely. If the hand and ear or for that matter tissues of greater depth be exposed to the action of red light, the tissues are transillumined by it.

That this energy penetrates without doing work seems incomprehensible. True it is the energy that is absorbed which does work, but red light energy must either be absorbed or transformed in the deeper and non-translucent tissues.

Any energy capable of acting upon the skin, as do the chemically effective frequencies, blue, violet and ultra-violet, is an appreciable power. But they do more than that as has been shown in considering the physiological action of light upon the blood. As a green leaf absorbs all the waves except the green which are reflected, and a red rose absorbs all waves but red, even so, then according to physical laws must the red medium of the blood absorb all waves except the red and that absorption means work done, energy imparted, just as in the case of plants.

"The extinction of energy in space or its absorption and consequent disappearance in matter is a deep-seated fact in nature. The appropriation and selection of waves by matter and their eventual return to space constitute the life of the universe, the ebbing and flowing of cosmical tides."

To the author's mind it does not seem that living organisms, showing as they do so close a relation to and dependence upon the radiant energy of the sun, are any exception to the physical laws governing other forms of matter. The blood shows its absorption bands and is fluorescent, the lymph serum is fluorescent also, and it must be that the penetrant frequencies of light energy affect other tissues than the skin, for all energy that is absorbed produces an effect in some way. All the energy of the spectrum is chemical but with a difference. In relation to the skin superficies of the living organism, the higher and shorter frequencies are intensely chemical. May it not be that the longer and slower frequencies, red, green and yellow are chemical in relation to

other structures of the body? The latter are known physically to have a much more powerful effect on certain substances than the shorter and higher frequencies; for example, on dilute solutions of nitro-prusside of sodium with sulphid of ammonia, on green vitriol, on metallic acid and arsenious acid, on sulphuretted hydrogen, sulphid of sodium, on cyanin and on certain plant pigments, chlorophyll, etc. From the action of light energy upon plants, it is very clearly established how important these longer and slower frequencies are for their growth and nutrition.

Speculation is not proof, neither is an absence of evidence. It has been the author's hope that the way might open in the midst of a busy life to help to an elucidation of these questions. Here, however, it is only possible to suggest the possibility of such a biological action and express the hope that careful investigations may be inspired to determine whether or not an exposure of the different tissues of the body to the action of the energy of the various parts of the spectrum is productive of results. The author is convinced that such investigations would neither be negative nor without great value. According to L. Cadmus[1], the coloring matter in dogs' gall is quickly oxidized, turning green and then losing its color in the presence of oxygen by the action of light.

The serum of horses' blood is subject to the same phenomenon, i.e., it first becomes green and then loses color when it is kept accessible to oxygen with access of light.

That there is then an effect from light energy upon the living organism is shown: (1) By its irritant effect upon the skin, intense light producing inflammation. (2) By its action upon the sweat glands promoting perspiration, this is true of chemical light energy as well as of thermal. (3) By its direct action upon the blood and the blood vessels, dilatation. (4) By exposure of large superficial areas of the body to the action of intense light energy there results an increased amount of blood in the superficial vessels and a depletion of the internal organs or viscera. (5) By a direct or indirect influence light energy modifies the transmutation of matter. (6) By the action of light energy in relation to motor excitation. (7) By its parasiticidal powers. (8) An excess of light stimulus (in common with too great an expenditure of any energy) is destructive and paralyzing. By it dermatitis, a prolonged erythema with tendency to recurrence and insolation are produced.

[1]Freund.

CHAPTER VIII.

Sun Baths. Arrangements of Solaria, Methods of Use and Therapeutic Indications. Tuberculosis of Joints, Pulmonary Tuberculosis, Anæmia, Neurasthenia, etc.

Sun Baths.

The Chemical Intensity of Sunlight Dependent upon the Season of the Year, Time of Day and Atmospheric Conditions.—Unfortunately the sun's radiant energy is not always available for therapeutic purposes. It is not a matter of dependence upon the weather only, but upon other circumstances which affect the chemical intensity of the light. In considering light sources in their relation to therapeutic work, there must be distinguished the difference between the visual interpretation of light which is its physiological power or optical brightness, and that which is interpreted by its chemical action upon photographic plates, upon bacteria, or in the production of characteristic light erythema of the skin.

The chemical intensity of sunlight does not coincide with its optical brightness. The former varies with the season of the year and the time of day; i.e., with the sun's height in the heavens. There is the summer solstice and the winter solstice to be reckoned with, the morning ascension, the noonday maximum and the afternoon decline. In summer, for example, the chemical action of the sun and the blue light of the sky are much more powerful than in winter. It is weakened in the spring and again in the autumn, reaching the minimum about the 21st of December. It is less in the morning and in the evening than at

midday when the sun is at the zenith. During the height of the summer the hours between 10 A.M. and 5 P.M. are the best. In the winter, however, it is necessary to wait until a later hour in the morning, and to limit the afternoon hours. The atmosphere also affects the chemical intensity of the sunlight as well as its optical intensity. The latter is weakened by about one-fourth during its passage through the atmosphere. There is a much greater loss of chemical energy than optical, and this loss falls most largely upon those frequencies so useful in chemical change, as in agitation of bacteria and in exciting skin erythema, viz., the ultra-violet. They are absorbed in their transit from the sun to the earth.

Solaria or Sun Baths.—"Man lives only by the radiance from the photosphere of the sun."[1]

In this radiance provided by nature there is available not only for purposes of hygiene and sanitation, but therapeutics as well, the best possible form of light energy. In only one class of therapeutic work can exception be made to this rule, and that is in the treatment of skin lesions, where a concentrated light energy of intense chemical activity is required. That is to be had from the radiant energy of the sun but not at the surface of the earth, as it is absorbed in transit from the sun by the atmosphere. Therefore the electric arc, a radiant sun in miniature which can be used at its source is preferred.

By this solar energy everything within its radius is purified, every object it penetrates is disinfected, and as these pages have abundantly shown, every known form of germ life is either destroyed or its development arrested by the action of light energy. On clear bright days even in the more northern parts of the United States there is to be had a more powerful source of light than can be obtained artificially, while in the more southern parts of the country this radiance is of still greater energy, and, therefore, better

[1]E. Larkin: Radiant Energy.

for therapeutic purposes. If the sun had no atmosphere the surface would shine at least two or three times brighter than it does with a blue-violet color, like the light of an electric arc, playing between two carbon terminals.

When the sun is on the meridian, and allowance is made for absorption by air and glass, it illuminates a screen 70,000 times as strongly as a standard candle placed at one metre from the screen. (A standard candle adopted by physicists is made of sperm and burns 120 grains per hour, or 7.776 grams.) The distance of the sun is 150,000 million metres. Square this, multiply the product by 70,000, and the result comes out 1,575,000,000,000,000,000,-000,000,000 candle-power. This is the quantity of light emitted by the sun, and is different from the intensity, for an immense surface, even if not very brilliant, can radiate a large quantity of light, while the quantity of light emitted by any square unit, as a square inch or centimetre, determines the intrinsic brilliancy. A mathematical computation shows that the sun's carbon winding sheet is 190,000 times brighter than the candle flame, and 150 times brighter than a calcium light, and from two to four times more brilliant than the electric arc light, all of which lights appear as dark spots when held between the eye and the sun.[1] In this solar energy is to be found the simplest and most natural method of using light therapeutically.

The sun is only a private in the host of heaven, a single star among millions, but he alone among the countless myriads, is near enough to affect terrestrial affairs in any sensible degree, and his influence upon them is such that it is hard to find the word to name it, it is more than control and dominance. He is almost absolutely in a material sense the prime mover of the whole. To him can be traced directly nearly all the energy involved in all the phenomena, mechanical, chemical or vital. Cut off this energy even for one month and the earth would die, all life upon its surface would cease. This fact has always been more or less dis-

[1]Young.

tinctly recognized, but a practical application of its truth is not always made even by the physician, whose duty it is to bring to bear all forms of energy physical and medicinal in the prevention and treatment of disease. The daily detailed application of large and universal truths in nature, too often escapes observation. From earliest times the material supremacy of the sun has always been recognized by thoughtful minds, and for centuries its life-giving powers have received recognition. His royal majesty, the sun, has been made the foundation of religious systems, as with the Persians. Says Young,[1] "It has been reserved for modern times, and to our own century (the twentieth), to show clearly just how, in what sense and how far the sunbeams are the light of earth, and the sun himself the symbol and vicegerent of the Deity. The two doctrines of the correlation of forces and the conservation of energy, having once been distinctly apprehended and formulated, it has been comparatively easy to confirm them by experiments and observation, and then to trace, one by one, to their solar origin the different classes of energy which present themselves in terrestrial phenomena, to show, for instance, how the power of waterfalls is only a transformation of the sun's heat."[2]

> Sunshine, though broken in the rill,
> Though turned astray, is sunshine still.[3]

The same thing, continues Young, is true but a little more remotely but just as certainly of the power of steam, of electricity, and even of animals. To-day the thought is familiar, but still the truth is often unheeded.

Whatever work is done, is by the undoing of some previous work.

When we come to inquire for the source of the energy which lifts the water from the sea to the mountain-top, which decomposes the carbonic acid of the atmosphere and

[1]The Sun.
[2]The Sun, Young.
[3]Lallah Rookh, The Fire Worshippers, Moore.

plant-foods of the soil, which builds up the hydrocarbons and other fuels of animal and vegetable tissue, we find it always mainly in the solar rays. Mainly because, of course, the light and heat of the stars, the impact of meteors and the probable slow contraction of the earth are all real sources of energy and contribute their quota, but compared with the energy derived from the sun, their total amount is probably something like the ratio of starlight to sunlight, so small that it is quite clear, as has been said, that "a month's deprivation of the solar energy would involve the utter destruction of all activity upon the earth." It is not only natural, therefore, that modern physical science but medical science as well should make much of the sun. The study of solar phenomena and their relation to health and disease should be pursued with the greatest interest and solar energy turned to account in maintaining the one and combating the other. The beneficent action of this energy was appreciated to the full by the ancient Greeks and Romans with their convenient even luxurious solaria in which they could expose their nude bodies to its action. The lessons they learned from their practical experience should have remained with us to our profit.

The Construction of Solaria or Sun Baths.—These may be elaborate and expensive or very simple and inexpensive. Wherever and whenever the sun shines and there is to be had a few cubic feet of space, whether within or without doors, there is the means to the end. An upper room no matter how small may be utilized and the light permitted to fall in through an open window or in colder weather through the glass of the window. A more pretentious sun room can be constructed with glass for its roof as well as for the sides, arranged as in a photographer's gallery. In either event there should be provided, according to the case, the means of reclining or of walking about, with the nude body exposed to the action of solar light energy. Verandas can also be utilized in similar fashion. If a glass enclosure is not possible, screens of sufficient length may be used. The light should fall perpendicularly upon the exposed superficies. Where the flat roof of a house offers a suitable resting place for a small roofless cabinet, an ideal sun bath may be constructed. In the small areas back of city houses a similar opportunity is offered. In them a roofless cabinet or a roofless tent will suffice. The interior can be provided with an easy chair, a couch or, if the patient's condition requires exercise at the same time, there is nothing needed but the tent enclosing walls. These should be high enough to secure the necessary seclusion from observation. Large yards may be arranged for solaria by surrounding them with high and continuously boarded fences. The interior can be arranged for all classes of cases, those requiring repose as well as those requiring exercise. These sun yards as well as sun rooms should be provided with the means of suitable hydriatic applications. If sun baths are administered in the room of a house or on the roof or yard of the same, the bathroom facilities will suffice. In more ambitious sun rooms or sun yards in connection with sanitariums, these facilities as well as provisions for massage and an alcohol rub, should form a part of the equipment. There are comparatively few sick rooms, taking the country as a whole, which cannot be converted into a comfortable sun room at some time between the hours of 9 A.M. and 3 P.M., when the sun's energy is most effective. To this end the bed or a cot can be placed directly before the window from which the sash has been removed and the patient placed thereon with the entire nude body exposed. If too cold to permit of the removal of the sash, the exposure may be made to the light after passing through the glass. Luckily there is but little loss here of the short and high frequencies or the ultra-violet because they have already been absorbed by the atmosphere. The sun's energy, with its complex of frequencies, its richness of those of the blue region, can be used by every practitioner in his daily rounds to the good of his patients, and when to the influence of light there can be added that of the air greater good will follow.

It is a simple matter for example in the dressing of a wound, of an open malignant process, where the patient lies in bed in a beautifully sunlit room, to direct that the bed should be moved into the sunlight and the one or the other exposed to the action of the sun's radiant energy not only during the process of dressing but at other times as well. The action may be limited to the visible chemical frequencies only if for any reason the thermal energy is undesirable by placing either panes of blue glass in the window or permitting a blue glass screen to intervene between the patient and the window. To illustrate: The author was recently called in consultation to a patient who for over three years had an extensive open sore as the result of the removal of a cancerous breast by means of pastes. The sore had never healed, and the condition had been aggravated by daily exposures for almost one and a half years to the X ray. The patient's skin was tanned until it resembled a negro's on the entire right side of the thorax from the clavicle far below a line drawn from the sternum and extending under the arm and far down the posterior thoracic walls. There was a large cavity in the axilla, the right arm was enormously swollen, metastases had taken place in the left breast, the discharge was foul and the patient was worn with the pain of this extensive destructive lesion. The attending physician wished to know if the use of light energy would render life any more tolerable and wished the writer to advise as to a practical form of apparatus for the purpose. A considerable experience with the most desperate of inoperable pelvic cases, in which light was used as an adjunct to the X ray, had justified the opinion that by its use, (1) the pain and discomfort would be modified, (2) the odor controlled and (3) a bare possibility of stimulating the healing process.

Immediately upon entering the patient's room, the author was struck with the ease and facility with which the lesions could be kept for from 3 to 4 hours daily under the direct influence of solar energy, instead of being carefully secluded in the dark by interminable dressings. The windows were west and large, the river lay just below to serve as a mirror for the reflection of the waves of light.

Baradat[1] recommends the giving of sun baths upon the sea, where the light is reflected by a vast mirror—the waves. This reflection of light by the waves of the ocean is an important factor in the good results obtained from sending tuberculous patients to certain seaside resorts noted for their efficacy, as at Mentone on the Mediterranean. The conditions for exposure to solar energy were ideal and the instance is related here that the reader may see and avail himself of every similar opportunity. The most powerful agents in our possession for the inhibition and destruction of micro-organisms are sunlight, fresh air and abundant nourishment. These were all provided in abundance, the latter was the first consideration and the saving clause in the case was the patient's good appetite, digestion and nutrition. The sunlight was at hand and was a factor in the well-being of the patient from its general diffusion in the room, but the concentration of its energy upon the sore itself, despite the well-known fact that open wounds do better than those that are shut in, had never been thought of. Thus every day we ignore the simple means to the end in our desire to reach out after the new and little known.

Willard,[2] in considering sunshine *vs.* X rays in the treatment of tuberculosis, says: "In my own hospital wards I have always considered the sun porch as the most important of all the means of cure. Every tubercular joint confined to bed, either with horizontal extension or with fixation or traction of joint, spends the entire day at all seasons lying directly in the sunshine, his eyes and head being protected by a green shade attached to the head of the bed. The effect on health, appetite and cell resistance is simply marvellous. When able to walk about, patients are encouraged to play in the sunshine, not in the shade. I have not infrequently

[1] Zeitschr. für Tuberculose und Heilstättenwesen, 1903, Bd. V. Heft I.
[2] Journal of the American Med. Ass., July 18, 1903.

sent out into the sunlight and fresh air apparently hopeless cases of joint disease with lardaceous organs, and have had them return with sinuses healed, waxy changes arrested and health restored. Of course, it is necessary that surrounding conditions, even in the country, shall be healthful, since many farmhouses are unsanitary in the extreme. In the treatment of tuberculosis of the joints not only are mechanical and operative measures necessary, but all the accessory conditions of health are essential: a superabundance of easily digested and nutritious food, and clothing adapted to the surrounding conditions, in addition to the sunshine and air. There are few individuals who have not observed the influence of darkness and poverty and vice on the general health, and yet few physicians realize the importance of securing the brighter and better conditions. The time is near at hand when sanatoria for the treatment of tuberculosis of the hard parts, as well as those of the soft tissues, will be established. Outdoor life in tents, either in the pine forests or in the hospital grounds, promises a simple practical application of the principles enumerated. Cheeks will grow more rosy, flesh will increase, energy will improve, and resistive power will speedily be such as to control and overcome the tubercle bacilli.

"McKenzie and Galloway[1] have also adopted this most excellent principle of treating cases of tuberculosis of joints in the open air by having them live in tents, thus giving patients all the advantages of sunshine and fresh air that are now in vogue in the lung tuberculosis sanatoria. The appetite is greatly improved under such conditions; more food is taken, and it is better digested.

"Dr. Flick's regulations at the White Haven sanatorium for consumptives are just as applicable to joint tuberculosis as to phthisis cases; patients to live in tents and to spend their life absolutely out of doors, air to circulate freely through sleeping apartments, ample bed covering to be supplied. Each patient to take at least 3 quarts of milk and 6 eggs a day; more if possible. In addition, a good dinner in the middle of the day, and a light breakfast and supper. Dinner of roast beef, vegetables and dessert. The gain or loss in weight are the best indications for adaptation of treatment and food.

[1]Trans. Amer. Orthopædic Ass., XV., 1902, p. 10.

"Poncet, of Lyons, and Perdu and Blanc[1] have also applied the method practically by exposing joints covered with iodoform gauze to the direct action of the sun for hours in the day. As the case recorded by them, however, had had a previous excision of the knee, the report only shows that the sun's rays acted helpfully in the cure."

There are to be obtained distinct effects from the use of sun baths: (1) A tonic effect; to this end a short exposure of the entire nude body to the solar energy is required. (2) An eliminative effect; a prolonged exposure without any attempt to minimize the thermal energy. (3) A nutritive effect; a prolonged exposure modifying the temperature in order to secure the action of the chemical energy where it is desirable to profoundly influence the nutrition of the deeper tissues.

The latter is the method chiefly used by Finsen in his sun baths. The patients promenade naked in a sunlit yard, where everything is done to keep down the temperature of the skin. To secure this result the ground is frequently sprinkled or if necessary shower baths are used. Here the purpose is not to have a thermal effect but a chemical one only. By the penetrability of the blue-violet frequencies and their chemical energy they are able to profoundly modify the nutrition of deep-seated tissues and organs. In the passing and repassing of the circulating blood stream during such a sun bath, every drop of blood is brought under the influence of the light and revivified. The impartation of energy to the storer of oxygen, the red blood corpuscle, is of first importance.

In the second instance, it is not alone a question of the

[1]Annales de Chirurgie et d'Orthopædie, Vol. XIII., 1900, p. 19.

chemical action of the penetrable blue-violet frequencies, although these are still active, but of the thermal as well, emphasizing the effect of the chemical energy upon the skin. An active condition of the sweat glands is induced by their combined action, which, however, may be brought about by either the one or the other alone. A slight perspiration is induced in the electric arc bath, always noticed in the palms of the hands and over the sternal region first. This is never a warm bath. When the sun's heat or heat from other sources is used extreme sudation is established. The use of sun baths in this way is indicated in all conditions where an eliminative effect is desired primarily, as in obesity for example. In the first instance it is the tonic stimulating effect of the sun's light which is desired, and this is usually in a class of cases who are unable to bear an undue expenditure of energy of any sort. Under this head may come convalescent patients, who are still too feeble to withstand this mighty energy. A longer exposure than 3 to 5 minutes in very feeble patients may produce headache, lassitude, insomnia and depression.

Light and Air Baths.—When the baths are administered in the open air, the action is due to the conjoined influence of light and air. These should be administered with little or no clothing for a period of from 2 to 6 hours. To keep themselves warm patients should do some manual work, engage in gymnastics, or have massage. These baths should be taken morning and evening, with a sun bath or hot bath at midday. The effective factors with these baths are regarded as the thermal stimulus, the increased activity of the skin through the radiation of heat and the influence of light on metabolism. The same factors are operative in prolonged sun baths in the open air where no effort is made to eliminate the thermally active energy.

They are practically the same as considered under the second subdivision, save that the purpose of the latter may be obtained within doors. A light and air bath acts as a general tonic to the nervous system, they are also very

useful in the treatment of obesity, and are good in congestion of the internal organs. The action of the heart and the kidneys is stimulated by them. They have been likened in their effects to those of the water cure.

Physiologic Action of Sun Baths.—Under this head must be included all those physiologic changes which have been discussed under the physiologic action of light. It is an influence due not to a single frequency or group of frequencies but to a complex of all the frequencies of the spectrum. These frequencies are thermal, luminous and chemical in relation to the different structures of the body, producing, therefore, the reaction due to their combined influence. Thermal energy gives rise to an increase in the bodily temperature. This is also true, but to a less degree, of the chemically active energy. The thermal effects then produced are practically the same as those induced by other sources of heat, save that they are unaccompanied by the depressing effects so often experienced by the use of hot air, water or vapor. This is by reason of the chemically active light energy conjointly active with the thermal. The thermic reaction stimulates the heart, brain and other organs, and there is an increase in metabolic activity as well. This elevation of temperature may rise to 40°C., 104°F. Kellogg found that there was an increased production of carbonic acid, indicative of an increased consumption of hydrocarbon and carbohydrates, which occurs also when the body is exposed to cold. There is likewise an increased oxidation of proteid, a characteristic effect of all the measures which raises the temperature of the blood. From the thermic stimulation there results a dilatation of the cutaneous blood-vessels (evanescent as compared with the dilatation produced by chemical light energy). This in connection with the more energetic action of the heart, the quickened circulation, tends to accelerate metabolism throughout the entire body. The violent and prolonged hyperæmia of the skin induces a determination of blood from the internal organs. By the overfilling of the cuta-

neous vessels a considerable amount of blood is diverted from the interior of the body, since when filled, the vessels of the skin may contain one-half to two-thirds of the entire amount of blood within the body. Naturally a draining of all the viscera results, establishing thereby a collateral anæmia in the brain, liver, kidneys, stomach, spleen, and other viscera. The drowsiness which ensues is a manifestation of cerebral anæmia. Because of this, the patient often falls into a profound slumber. By the thermally active energy of the sun a profound effect is produced upon the nervous system. This is also true of the chemically active energy, and the one or the other is the more active according to the manner of administration of the sun bath. Simultaneously through the influence of the thermally active energy the sweat glands are stimulated to greater activity and very active perspiration is induced. The amount of sweat may be increased from the normal of 2½ ounces in an hour to as much as 2 or 3 pounds, even more in an hour, especially if the patient is exercising actively.

The action of the chemically active light energy upon the peripheral nerve endings also exerts an influence upon the sweat glands. The effects obtained may be the one of three, (1) from a simple tonic action, where the combined energies of the different frequencies of the spectrum are utilized over short periods of time; (2) by subjecting the patient to the influence of the full energy of the sun over comparatively long periods of time; (3) from the influence of the chemically active energy whenever a means is used to keep down the thermal effect, as by cooling the surrounding space, whether a sunlit yard or a sunlit room, by suitable means, sprinkling the ground, refrigeration of the room, ice or liquid air, and by douching the patient with cold water. In the first instance the action is that of a simple tonic, in the second profound eliminative effects, and in the third fundamental nutritive changes are established. Each has its recognized indication in the various conditions of disease, and the one or the other must be prescribed with

the same intelligent skill, basing the prescription upon physical properties, physiological action, and pathological conditions, as in the case of mercury or strychnia. It is not enough to tell a patient to sit or lie in the sun, but the points which have been enumerated must be carefully considered in order that the needs of individual cases shall be met. The sun bath should be given in the fresh air wherever possible. In this way it really becomes a light and air bath, and as such accomplishes a twofold purpose.

Sun baths are of benefit (1) by promoting perspiration. As the result of this action harmful and toxic products are eliminated. (2) By the stimulation of metabolism. (3) By stimulation of the nervous system, and (4) by the direct action of light upon the blood. This primary action upon the blood is after all the fundamental action, and upon it the round of physiologic changes known as increased oxidation depends.

As to the bactericidal action of sunlight under the conditions governing a sun bath, it is not active. This is by reason of the absence of a maximum of ultra-violet energy at the surface of the earth, and also by reason of the little penetrating power of these frequencies. There is, however, an abundance of blue, indigo and violet frequencies, and their bactericidal action is by no means to be disregarded. Still the primary effect in the sun bath, in bactericidal diseases, is not one of bacterial destruction but one of increased physiologic resistance. In this way the balance of power, so to speak, is with the individual and not the bacteria. By establishing normal physiologic conditions of circulation, nutrition and elimination, the influence of microorganisms need no longer be reckoned with. In all conditions of metabolic defect, and especially in conditions characterized by deficient oxidation, sun baths are indicated. Obesity, diabetes, and the alloxuric diathesis are notable examples, and in this class of cases a prolonged exposure to all the radiant energy of the sun is indicated.

The profound autointoxication of the patient suffering from chronic indigestion whose skin is dry, sallow, leathery, evidencing deficient oxidation, will be promptly relieved by the daily administration of sun baths. Under the influence of the sun's thermally and chemically active energy, the skin becomes moist, healthfully colored and smooth in texture because of the increased oxygenating power of the blood from the chemically active frequencies and the elimination of toxic products due to the free sudation established by the thermally active frequencies.

In no conditions is sunlight whenever it can be commanded, of greater avail than in anæmia and chlorosis. By the stimulation imparted to the oxygen-storing capacity of the red blood corpuscle, the entire blood stream is thoroughly oxygenated, even to the remotest part of the organism. Even though but a part of the body is exposed, the circulating medium passes and repasses through the superficial circulation of the part exposed until in a very short exposure, the entire blood stream is brought under the influence of the oxidating light energy. Still better is the result when the entire superficies of the body can be exposed directly to its influence, for to each square inch of surface there is an expenditure of energy, and when this is multiplied by the number of square inches of the body area, the amount of this expenditure is increased a hundred-fold. By its prolonged effect upon the circulation the spasm of cutaneous vessels, which results in chronic visceral congestion, is rapidly relieved. Elimination of toxic material takes place at the same time.

The sun bath is of very great value in the treatment of neurasthenia. When the conditions of season, weather or environment preclude its use, the electric arc bath satisfactorily takes its place. All forms of neuralgia dependent upon impoverished blood and conditions of malnutrition as well as those associated with the rheumatic diathesis are benefited by sun baths. These are mentioned in contradistinction to those neuralgias dependent upon a traumatism or of central origin. Where the neuralgic pain is due to an injury with the formation of an inflammatory exudate, concentrated electric arc light energy is indicated, if light energy is to be used.

When employed with the proper precautions Kellogg states that sun baths are of great value in myxedema and exophthalmic goitre. The author, personally, has had no experience in treating these conditions in this way. Wherever the condition is one involving the heart, great care must be taken in the administration of all forms of heat. This is true of sun baths in the same class of cases also, and to the end of preventing an untoward effect of the thermal energy upon the weakened organ, ice bags or a cold coil should be placed over the precordium.

Sun baths in common with artificial light baths are useful in Bright's disease and also in other forms of visceral degeneration, cirrhosis of the liver, for example. In these conditions great care must be taken in their administration. Neither too violent nor too prolonged expenditure of radiant energy must be made. The patient must be properly cooled after the bath, the means for that purpose selected according to the individual needs. In these cases, as a rule, the cold water plunge, swimming bath, cold douche even, are unsafe and the indication for a tonic application of cold is best met by friction with a cold mitten, a cold towel rub or a cold wet sheet used in the same way, the temperature of which should not be lower than 60°F. and for no longer than from 10 to 20 seconds. Reaction must be established in the gentlest and safest fashion, in order not to unduly load up weakened organs by the return of the circulating fluid to the interior of the body.

Sun baths are also of value in chronic rheumatism, in rheumatic gout, in tuberculous joint diseases, in tuberculosis, asthma, and also in affections of the skin and mucous membrane. In fact, the range of morbid manifestations in which sun baths are of value is just as wide as the entire range of disease. Seldom are the conditions such, save in

the very crowded centres, that this all-pervading radiant energy may not be utilized for the purposes of hygiene, sanitation and therapeutics.

Technique.—In so far as possible sun baths should be arranged to open to the south. The time of day in the summer may vary from 10 A.M. to 5 P.M. These hours will need to be lengthened in the morning and shortened in the afternoon as the season approaches the winter solstice.

The duration of a single exposure is governed by the object to be obtained as indicated and also by the season of the year, the condition of the atmosphere and the time of the day. The head and eyes should be protected from the direct solar rays by the use of colored glasses and suitable awnings or umbrellas. To this end the head should be protected. Parasols of dark color (black) should be used, or if the condition of the head necessitates greater precautionary measures, cold wet cloths should be applied, covered in turn with some dark fabric or a dark colored umbrella. Should the patient have previously suffered from insolation, the need for care is still greater. Nausea and other unpleasant symptoms may arise through an undue stimulation and over excitation of the brain and central nervous system. If the whole surface of the body is exposed to the direct solar rays, the head should be still further protected. This to avoid any direct action upon the cerebral circulation, as that secured indirectly through the action of the light upon the body circulation is sufficient.

The whole hairy scalp of men and children may be moistened, also the face. The same is advised in women, and where it is undesirable to wet the hair a napkin wrung out of water at a temperature of from 60° to 65° F. should be applied to the face and neck, and this may be supplemented at need by an ice cap to the head. The napkin should be re-wet with cold water if the exposure extends over a minute or two. The necessity for these precautions does not exist after patients have become accustomed to

the bath except in cases which have suffered from sunstroke.

The entire body should be nude. In sanitaria where common sunlit yards or gymnasiums are used for both sexes at the same time, the need for clothing may be met by the use of bathing attire. If clothing is necessary, it should be white or light colored, as a considerable portion of the light energy will reach the covered portions of the body through the clothing. Feeble patients should preferably recline during the exposure. Vigorous patients, on the other hand, may walk about the outdoor solarium, and, if provided with a gymnasium, engage in light gymnastics or games of some sort. If the purpose be to increase oxidation to as high degree as possible, as in obesity, diabetes and the lithæmic diathesis, active exercise is indicated.

Frequency of Treatment.—The best results are secured by daily exposures, and the duration should be increased from 30 to 60 minutes at least once a day, according to the patient's toleration.

Summary of Direct Effects of Sun Baths.—(1) A more or less pronounced erythematous reaction of the skin, leading to intense pigmentation and desquamation; (2) profuse perspiration; (3) rise in temperature; (4) nervous disturbances in unduly sensitive persons, and a pleasant sense of refreshment and comfort in healthy or less sensitive persons; (5) improvement of appetite; (6) improved spirits, and (7) better sleep. In a word, the general power of assimilation is promoted. In this way the vital energy of the body and its power of resistance to all injurious influences is greatly increased.

Sun Baths Indoors.—When sun baths are given indoors all hangings should be dispensed with, for by the time the light has filtered through them, even white muslin and lace, much of the initial energy is lost. Furthermore, they become dust laden and afford a suitable lodging for micro-organisms.

Direction of the Incident Light.—The light both indoors

and out of doors should preferably fall perpendicularly upon the nude body.

Insomnia forms an indication for the use of carefully graduated cold applications to the head. Care should be taken not to overheat the head during the bath. The beneficial effect of the cold application to the head may be supplemented by the use of a cold spray applied for 10 or 15 seconds to the legs and feet. Each pathologic condition must be suitably met in the after treatment. The cold douche or spray should be neither too intense nor too prolonged in rheumatism, gout and rheumatoid arthritis, for example.

Tubercular patients must be cared for carefully in this regard, and may not necessarily require the use of a cooling application. The systemic condition of the patient and the amount of reaction established by the solar energy must govern the physician's prescription. It may be well in some cases to use a tepid shower or a fan douche, or even the interrupted jet at the beginning of a treatment for the purpose of cooling a patient. For this purpose a temperature of from 75° to 80° or 85°F. may be used, and the duration of the application for from a fraction of a minute to a full minute.

After Treatment.—This should take the form (1) of cooling douches, sprays, local applications or rubs; (2) of exercise. In both instances the object is to promote a healthful reaction. In cases for which an administration of a cold douche is indicated, it should preferably be made to impinge upon the legs, back and liver, care being taken to avoid the precordial region. In cases requiring great care in this particular the patient should preferably be cooled by a rub with a cold wet towel or sheet. The presence of skin eruptions forms a contraindication to friction, nor is it best to use very cold applications. A rain douche at 85°F. is recommended. In this class of cases the necessary reaction would better be established by exercise. In the treatment of painful joints, the force of the impinging douche should not

be permitted upon a sensitive part, as the pain will thereby be increased.[1]

Contra-Indications and Precautions.—The sun bath is contraindicated in all febrile disorders, save in cases of pulmonary disease with slight elevation of temperature. Whenever the febrile activity is of a decided character in this class of cases the use of sun baths is contraindicated, however. Or in this same class of cases, if there is no great rise in temperature, they should be limited to the tonic effect only, and to that end exposures of but a few minutes should be made.

When there is a disturbance of the functions of the body giving rise to an increased temperature, it is an easy matter to still further induce increased temperature, therefore the necessity for great care. The skin reaction is more severe in blondes than in brunettes and with the latter measures may be indicated to soothe the inflamed skin. For this purpose dusting with starch, talcum powder, or the use of oxide of zinc ointment may be necessary. If there is much swelling induced, cooling applications in the way of compresses may be indicated. The trouble is avoided as soon as pigmentation of the skin is established.

Conclusions.—The body superficies in part or as a whole, according to the environment of the individual, should be exposed daily to the influence of the radiant energy of the sun. This should be done for the purpose of maintaining normal circulatory, oxidative and eliminative conditions even in health. The custom of many individuals of spending hours of the day during their sojourn at the seashore clad only in scanty bathing attire is a commendable one, from the point of hygiene, however a critical and perverted mind may regard it from a point of taste. Less cumbersome and light-excluding attire at all times and seasons would redound to better health; while too much stress cannot be laid upon the

[1]For full directions as to the scientific use of hydriatic measures either alone or in connection with sun or artificial light baths, the reader is recommended to the work of Dr. Simon Baruch on this subject.

necessity for abolishment of curtains, hangings and draperies, no matter how much their presence appeals to the artistic sense.

The exposure of the unprotected head to the sunlight, if the energy be not too great, will not only often prevent the premature falling of the hair, but it will in many cases arrest the trouble. For a number of years it has been the author's custom to direct patients thus troubled to go without their hats during their summer's vacation and even in the city. Especially has this been done for men patients, where treatment has been instituted by means of artificial light in the office. The result has always been good wherever destruction of the hair follicles had not taken place. The good effect is brought about in two ways (1) by the direct action of light upon the skin and (2) by the absence of the accustomed pressure of the hat, interfering as it does with the circulation. The many cases of eczema that recover in the summer only to reappear in the winter when there is less light and the parts are more completely covered, seems to illustrate that in the radiant energy all about us, nature has abundantly provided the means to the end.

Action of Light Energy *vs.* Open Air on Granulating Wounds.—In advocating the open-air treatment of granulating wounds open by day, with dressing at night, the mechanism of this ærotherapy is attributed by M. Wagner to the action of the air which excites the epithelial cells; and at the same time, by the desiccation of the wound causing the death of the virulent germs which are found there.

It is stated by M. Romme[1] that M. Bloch has given a different explanation, to wit, that it is the white light of day which invigorates atonic wounds, and which by desiccation, forms a pellicle furnishing a protection against the germs of the air. The author agrees with Bloch in believing that

[1]Desiccation by Phototherapy in the Treatment of Granulating Wounds. Revue Internationale d'Électrothérapie, Jan., 1904. Abst. from Presse Medicale.

it is the energy of light which is effective in facilitating the healing of wounds exposed to its influence.

It is also unquestionably the action of the solar light which has contributed to the good results noted by Abrahams in skin conditions by sea-bathing.

In relating his experience as to the beneficial effects of sea bathing in some forms of skin diseases, Dr. Robert Abrahams[1] attributes the good results to the prolonged immersion in the salt water, the friction caused by the bumping of the waves and the rubbing of the sand against the surface of the skin, thus removing incrustations and impurities and giving freer play to the action of the salt water, and to the drying of the residue of the salt water upon the body by the sun and air. He loses sight completely of the influence of the sunlight and especially the ultra-violet which so far as it exists in sunlight at the earth's surface is more in evidence at the seashore than anywhere else save at high altitudes. Dr. Abrahams tried the effect of sea water confined in a small space indoors on the same class of cases without obtaining any salutary results whatever.

[1]New York State Med. Journal, Jan. 1904.

CHAPTER IX.

Electric Arc Baths. Arrangement of Light Mechanism, Methods of Use and Therapeutic Indications. Pulmonary Tuberculosis, Bronchitis, Bronchial Asthma, Anæmia, Neurasthenia, Locomotor Ataxia and other Nerve Disorders.

The Electric Arc Bath.

Electric Arc Mechanisms and Methods of Use.—An experience extending over a period of 11 years with the electric arc as a therapeutic agent, both in private and clinical practice, has established beyond question the writer's confidence in its value. During this time it has been in almost daily use. Important as the rôle of light energy is in relation to skin pathology, it is by no means confined to it. It has a place in general medicine of equal if not greater importance. A description of the apparatus and some of the results obtained have been embodied in a report on "Electric Light as a Diagnostic and Therapeutic Agent,"[1] and "The Electric Arc Bath,[2] a Clinical Report," as well as in subsequent contributions to current literature. The results obtained in the beginning with a somewhat crude arrangement of an electric arc led to a further elaboration of the apparatus for its application, consisting of the "Cabinet" or "Bath" described in the writer's papers above alluded to, and also by Imbert de la Touche in the Revue d'Électrothérapie, April and May, 1896.

[1]Translations of the Amer. Electro-Therapeutic, April, 1904. Journal of the American Medical Association, 1895.

[2]Transactions of the American Electro-Therapeutic Association, 1898. N. Y. Medical Journal, Jan. 28 and Feb. 4, 1899. "The Electric Arc Bath," by Margaret A. Cleaves, M.D.

A description not only of this cabinet, but of the various arrangements of arc lamps springing into use, following upon a presentation of the physics of light and especially of the electric arc may help each reader to an elucidation of the question as to the simplest and most advantageous arrangement of electric arc mechanisms for therapeutic purposes, the one capable of securing the best results and, at the same time, of being operated at a minimum of time, energy, and expense. In discussing the subject of light baths, too great care cannot be taken to discriminate as to the character of light used, for only in this way can scientific progress be made and accurate conclusions be reached. The electric arc by reason of its physical properties offers advantages not possessed in the same degree by any other source of light.

In the electric arc there is to be had a miniature sun comparable for therapeutic purposes in every respect to the radiant energy from the sun and for purposes of localization, when tissue reaction is desired as in skin conditions, it is a source of the most intense chemical activity or ultra-violet light, superior to sunlight at the surface of the earth.

When sunlight is obtainable it is to be preferred over any source of artificial light for the therapeutic uses of light energy in general conditions. For, it is not only the radiant energies of the sun which are active, but the fresh air as well. The electric arc whether with carbon, carbon and iron, or iron electrodes only, is very rich in the short high frequencies or ultra-violet frequencies, and therefore is to be preferred where an intensely chemical energy is necessary, as in skin conditions. No matter if the sun is available, the arc is the better source of light energy for skin localization.

For the use of light energy in general medicine, however, the indications are equally well met by means of sunlight. But there are many days in the winter season, especially in all northern climes, when the sun does not shine, when the need of the patient, suffering from anæmia, malnutrition, phthisis, bronchitis, tuberculosis pulmonalis, etc., for sunshine is imperative. This is true of crowded centres, such

as New York, London and Chicago, for example, where by reason of the narrow streets and tall buildings, a considerable proportion of the population are obliged to live in rooms, apartments, houses even, into which the sun never falls, or but to a limited extent. There is no opportunity of flooding their every corner with the sun's energies the whole range of the spectrum active at the surface of the earth, than which no better hygienic or sanitary influence exists.

These conditions are not only true of the extremely poor, but of people in comfortable circumstances as well, in the larger cities. There are also from five to six months of the year when the sun is obscured often and for days at a time. During these periods every one suffers from the lack of its beneficent influence and conditions are engendered unfavorable to health. But the loss, though temporary, of radiant energy, falls most severely upon those who are handicapped by disease. Therefore radiant energy baths should be the logical outcome of this need, and form a part of the equipment of the physician, who by every rational means in his power endeavors not only to combat, but to prevent disease. The electric arc as an artificial source of radiant energy is available over a considerable extent of the country by reason of the fact that it is very extensively used for the purposes of street illumination. It is not difficult of manipulation, and cabinets or rooms for its use are easily and comparatively inexpensively constructed.

Physically, the arc, as has been stated, is comparable to the sun as a source of energy. Unlike the incandescent light bath, it is not a heat bath. In fact, the heating effect is subordinate to the chemical effect. The effect of the electric arc bath is not confined to the action of high frequency waves alone, the low frequency waves as well as the ozone which is generated, play an important part in nutritive change. From the administration of an electric arc bath there is obtained an action upon the skin, the patient experiences a pleasant and slightly prickly sensation. There is produced, even from a short exposure, upon the skin of

some patients a slight erythema, while with others there is but little such effect even from long exposures. The face assumes a normal rosy coloring and an appearance of refreshment and repose on emerging from the bath is always observed. From the administration of the electric arc bath the author has noted the establishment of circulatory changes with a uniform regulation of the heart's action, as evidenced by improved volume and slower pulse rate, the augmentation of the temperature, increased activity of the skin, fuller and slower respiration, gradually increased respiratory capacity, and diminished irritability of the mucous membrane in tuberculous, bronchitic or asthmatic patients. There is also lessened discharge in those patients suffering from catarrhal conditions of the nasal passages. In diseases of the respiratory system, a soothing effect upon the mucous membranes is always experienced, while cough and expectoration are diminished.

Finsen[1] first published his observations upon the stimulating action of light in 1895. At the same time he pointed out that the chemical rays might be useful in the treatment of disease. At that time he did not have in mind the use of concentrated light, which has since made his name famous, but the use of general light baths, that is, the exposure of the whole body to the chemical rays of light. These he has also used, and speaks of them always as chemical light baths. By them is to be understood a bath of the same character as first used by the author in 1893, reported to the American Electro-Therapeutic Association in 1894, and in a more perfected form in 1895. A description of this bath with a report of cases treated and results obtained was presented to the American Electro-Therapeutic Association at its eighth annual meeting in Buffalo, 1898, and was published in the Transactions of the same year.

Both reports were also published in the current Medical Journals.

[1]Journal of Physical Therapeutics, Oct., 1900. A note on Light Baths, N. R. Finsen.

Chemical light baths have a very decided action upon the skin. This was indicated by the results obtained from the use of the electric arc bath in the author's experience, but it has been fully established by the experimental work of Finsen.

The dilatation of the capillaries and blood vessels of the skin by the action of the chemical frequencies is not an altogether acute or rapid process, but is one of long duration. By reason, therefore, of a light bath there is established a dilation of the cutaneous vessels, which determines a more active supply of blood thereto. This in turn unquestionably influences favorable nutrition, enabling the skin to better perform its function. But this action is not alone confined to the skin. It penetrates farther, and is much more far-reaching in its beneficent influence.

Description of Arc Light Cabinet.—The cabinet used by the author for the past 9 years is 6 feet long, 2½ feet wide, and 7 feet high, built in the corner of one of the office rooms. It is entirely closed in, save for an observation window, which can also be utilized for the admission of fresh air, if desired. It is lined with zinc throughout in order to prevent any danger of fire from a fragment of burning carbon. This zinc lining is painted white, and finished with white enamel in order to afford the best possible reflecting surface for the light. The lamps, two in number, are suspended one at each end of the cabinet, with a shield of glass directly underneath to prevent particles of carbon falling upon the patient. The light of the arc is projected toward the patient's body by means of reflectors placed back of each arc. These reflectors or mirrors are of glass, silvered at the back and concave. By their use the operator is enabled to direct the beam of light at will upon the part of the body where it is desired to secure the action of the greatest intensity of the light energy.

The cabinet contains an ordinary wire-mattress cot, which is made up as a bed with fresh linen for each patient, and upon which the patient reclines.

Fig. 10.—Electric Arc Cabinet.

In the author's office the current is taken from the Edison incandescent mains at 110 volts pressure, and each lamp takes about 10 ampères at 50 volts, the remainder being consumed in the rheostat.

At the New York Electro-Therapeutic Clinic the lamps were on the Thomson-Houston alternating-current mains of 104 volts, and each lamp took 9 ampères at 48 volts, the remaining 8 volts being consumed in the rheostat.

Both equipments have given satisfaction, but the continuous-current arc lamps have been somewhat less difficult of adjustment, and, therefore, have required less care.[1]

As the patient lies at rest in the bath he is bathed in a flood of light emanating from sources of 4,000 total normal candle-power (the arcs of 2,000 candle-power each). While the patient's entire nude body should be exposed to the action of the light energy, exposures are sometimes made with only a partial undressing. The eyes are protected from the intense light by means of colored glasses, and, if desired, the face and hands may also be protected to prevent the tanning effects of the light or an artificial sunburn.

All patients, but especially phthisical and bronchial patients, are directed to breathe in deeply and fully while lying in the bath.

Practically the same arrangement, copied from the writer's, is in use by physicians in various parts of the United States. It was also copied in all essential points by Imbert de la Touche of Lyons.[2] In an article in the Revue Internationale d'Électrothérapie, April and May, 1896, he described the author's cabinet, and also his own modification, which consisted in placing the carbons at an angle, probably 45°. In this way the crater of the positive

[1]The ease with which both continuous and alternating current arcs may be operated is a matter of (1) a knowledge of the mechanism and (2) experience in handling them.

[2]A Novel Application in Therapeutics by Imbert de la Touche, France, Électrophotothérapie or Bath by Light, Revue Internationale d'Électrotherapie, April and May, 1896.

carbon served as a reflector enabling him to dispense with the reflector as used by the author, and to secure more of the energy of the *light of the arc proper*. In the author's cabinet but one patient can be treated at a time, and it is not, therefore, so desirable in dispensary practice, where it is necessary to care for a number of patients simultaneously, as a room arranged with one or more powerful arcs, 80 to 100 ampères suspended from the ceiling, and at the same distance from the floor as in the cabinet just described, i.e., 6½ feet.

The size of the room may vary according to the number of patients to be treated, or the facilities at the operator's command. It may be divided by screens or partitions as is necessary, and the couches can be placed radially from the centre, and in an inclined position looking toward the light. This is the arrangement used by Finsen in the administration of electric arc baths, the following description of which is from his pen:[1]

Finsen's Light Baths.—These consist of a circular room about 37 feet (12 metres) across, from the ceiling in which are suspended two powerful arcs, 100 ampères each, at a distance of a little over 6 feet (2 metres) from the floor. The room space is divided by means of partitions extending radially from the centre, which secures the necessary privacy. In the individual small rooms thus obtained, beds are placed in an inclined position. Upon these beds, with the body entirely divested of clothing, the patients lie, exposed to the radiant energies of the arc. These baths, as has been stated, are in no sense heat baths, and as a matter of fact, the temperature is so low that it is necessary to warm the rooms for the comfort of the patients; yet, notwithstanding the lowness of the temperature, the chemical action upon the skin is quite as strong as sunlight. A pleasant warming and tingling of the skin follows their use. The length of exposure varies from 10 minutes to an hour. In the author's

[1]Journal Physical Therapeutics, Oct., 1900.

cabinet[1] the exposures are from 15 to 45 minutes. Different patients differ in their susceptibility to the action of the chemical frequencies upon the skin. A very pronounced erythema in the more susceptible subjects may be produced in 10 minutes; in others, there may be only a slight reddening after an hour's exposure.

The electric arc, either in the form of a cabinet bath, or by projecting the beam of light on the part as with the marine searchlight, has given excellent results in the treatment of muscular rheumatism and the different forms of neuritis.

With cots of ordinary height, the distance of the patient from the arc would be the same as in the author's cabinet, i.e., 4 feet. Given lamps of the same electric power, and, therefore, capable of producing the same quantity of light, there will be approximately the same total radiant energy emitted in each instance, i.e., in the small cabinet or the large room, but the energy for each square inch of surface exposed to the light activities will be very much greater in the smaller space, owing to the reflection of light from the walls. Therefore, if the greater expenditure of energy is not desired, lamps of smaller ampèrage can be used which will minimize the expense for current. On the other hand, when indicated by the pathologic condition, the greater intensity per square inch of surface exposed would produce better therapeutic results. From the results obtained there is every reason to believe that two 10-ampère lamps in series would produce sufficient energy for so limited space. There is, however, no objection to using arcs of higher ampèrage if the operator desires, bearing in mind always that the amount of light emitted by the unit area is practically the same. To increase the amount of light emitted, the size of the crater must be increased in order to provide a larger unit of area.

There are also quadrangular cabinets, with the arcs fitted in each corner. In these the patient sits with his head

[1]Transactions American Electro-Therapeutic Association, 1898.

outside as in an incandescent bath. Such cabinets are used in Germany, and Freund refers to them as the arc light enclosed bath of Kellogg. The lamp mechanism is so arranged that the light energy can be thrown both upward and downward, and directed upon any part of the patient's body at will. Arrangements are made in these cabinets for the introduction of colored glass filters, according as to whether it is desired to use the visible chemical energy of the arc, blue glass, or to minimize the heat by the use of red glass.

Freund objects to the use of reflectors to intensify the light, on the ground that "burn-blisters" are liable to be formed on the part of the skin to which the concentrated arc light energy falls. The author has had no such trouble with 25-ampère arcs where the energy has been projected upon a part by means of a Mangin mirror. Another objection which he offers, accrediting the thought to Strebel, does not exist in fact, viz., the formation of noxious gaseous compounds (acetylene and other compounds of carbon and hydrogen), which he says are not only absorbed by the skin, but also escaping at the neck opening, may penetrate the patient's air passages. The author has fully considered under the physics of the electric arc the nature of the gases given off by it when in activity, from the physical chemist's point of view. From the investigation of the subject there is nothing to lend color to the thought that such gases generated during the activity of the arc exist in sufficient quantities to exert a deleterious action during the time the patient is exposed to their influence.

The reader is referred in this connection to the chapter on Physics of Light Energy, in which the nature of the gases given off by the active electric arc is fully considered.

The enclosed cabinet described in these pages has been continuously in use for 9 years. Exposures have been made from 15 to 45 minutes in length, to tubercular, asthmatic, bronchial, anæmic, convalescing grippe and bronchopneumonia, neurasthenic, neuritic, etc., patients not only

without bad effect but always with good and with, as has been stated, so immediate and favorable an effect upon cough and expectoration, that it has always been felt that there was effective some form of energy of a powerful oxidizing character other than the light energy. Ozone which from the most careful experiments is shown to be present, but not in large quantities, would produce this effect in respiratory conditions. The nitrous oxide given off in larger quantities does not seem to act deleteriously, nor does it when generated by the disruptive discharge of influence machines as they are used. The air of the rooms occupied by the latter as well as the air of the arc light cabinet, is deliciously pure, having the same odor and freshness as at the seashore or mountain top.

It should be noted, however, that the cabinet described is really a small room with large cubic foot space, and after these years of use, the author has not seen fit to change it in any particular save to lower the lamp mechanism a few inches. The window for ventilation should preferably be placed in the upper part of the enclosing side or end, as the impure air rises. If desired two windows may be provided, a lower one for observation and the ingress of pure air, and the upper one for the escape of impure air. In practice this has not been found necessary. Just here it may be well to say that the upper carbon should be positive, in order that the crater may serve as a reflector and the light energy be directed downward upon the superficies of the body. The placing of the carbons at an angle, as was done by Imbert de la Touche in his modification of the author's cabinet, enables the direction of the maximum light energy to the superficies of the exposed body.

Single arcs of from 10 to 25 ampères are also in use in the offices of physicians throughout the country and the effect of the light energy from these is heightened by the use of parabolic reflectors. In this way the light which would otherwise be radiated upward, is reflected downward upon the patient.

The small enclosed rectangular cabinet described by Kellogg and used in Germany, the author does not advise for arc light baths. The light energy, as well as the other activities of the arc, serves the physician's purpose better when diffused in larger cubic foot area. These cabinets as constructed in Germany are usually a combination of an incandescent and arc light bath, arranged so that the energy of both can be used at will, or either the one or the other separately.

This combination is not advised. The therapeutic indications for the incandescent light bath, which have been fully considered, are different from those of the arc, although they touch at points. But to secure the best results, these cabinets should be constructed on different lines as has been pointed out. This is not possible where one enclosing cabinet serves both purposes.

In the use of these various arrangements the patient occupies a recumbent or sitting position, and is, as has been stated, either wholly or partially divested of clothing.

In the writer's cabinet, and also in the room used by Finsen, beds are provided which make it possible for the patient by reason of the reclining position and protection from currents of air from underneath, to be entirely nude without chill or discomfort. This is not possible in the use of the marine searchlight, for example, unless the beam therefrom be projected into a cabinet, for by reason of the size of the beam and of currents of air only a partial exposure can be made. Nor is it desirable that all the patients for whom these baths are indicated should occupy a sitting position.

It is only necessary to keep in mind the condition of patients for whom treatment by means of an electric arc bath is indicated, to appreciate how essential it is, first, that the entire body be exposed to the action of light, and second, that it be administered so as to minimize the patient's discomfort, and avoid any danger of chill.

But while no better reasons exist than the well-being of

the patient and the exposure of the entire body to the beneficent influence of this bath of radiant energy, there are reasons dependent upon the physical laws governing light why one method of application is better than the other. Scientific progress will be much more rapid and sure if at the outset there can be secured to the physician, who may desire to avail himself of light as a therapeutic measure, an arrangement of lamp mechanisms capable of securing the maximum benefit with the minimum expenditure of time and electric energy.

With the arc suspended above the patient as in the author's cabinet, and also in Finsen's room, where the arc is suspended from the ceiling and couches arranged radially around it, the light falls perpendicularly upon the patient. This is correct according to physical laws. In this way the whole of the crater light and the light of the arc are thrown down upon the patient's nude body, thereby securing an irradiation of the highest chemical activity compatible with the ampèrage of the arcs used.

The field of usefulness of these artificial light baths energized by electric arcs is as broad as the domain of medicine itself.

In the writer's personal experience the non-concentrated light energy of the carbon electric arc has been found of great value, in both primary and secondary anæmias, malnutrition, neurasthenia, in neuritis and neuralgias, in tuberculosis of the bowels, in sprains and contusions, in eczema, seborrhœic eczema with loss of hair, psoriasis and in acne, as well as in respiratory diseases. In no one condition is it of greater value than in tuberculosis of the lungs.

The Electric Arc in Tuberculosis.

No countries suffer in the same proportion from tuberculosis pulmonalis as the British Isles. This, without doubt, is largely due to the absence of sunshine over prolonged periods of time, an untoward physical condition which is still further contributed to by the fog and dampness. In-

stead of the organism being bathed in sunlight for the most part, there are consecutive weeks and months in which the sun rarely shines. The absence of the sun's rays interferes with all the functions of the economy.

There can be no question but that the living organism is to be regarded as an energy transformer, and under normal conditions it would seem to functionate as a radiant energy transformer as well. By the absence of the complex of wave lengths from the sun, absolutely essential to its well-being, depressed and disordered function obtains. The influence of the chemical frequencies upon the blood stream, and especially upon its oxygenating power, is in abeyance; mal-nutrition results and the micro-organisms find a fit habitat for their development. Especially is this true of the *tuberculosis bacillus.* Patients suffering from tuberculosis are sent where? To a land of sunshine. When a climatic change becomes necessary the place selected, whether by the sea or inland, whether of ordinary or high altitude, is always a place where the sun shines, where for maximum periods of time the patient is under its beneficent influence. Not every patient can avail himself or herself of such a change. It may be absolutely imperative to remain at one's post of duty, wherever that may be, no matter how grave the impending danger. Work and a degree of ill health are not by any means incompatible, and the patient may so order his life as to meet the daily duties and at the same time have the treatment tending to a restoration to the normal.

It is possible in almost every city and village throughout the country, to have the means of subjecting the patient to the action of artificial sunlight, during the season when exposure of the nude body to sunlight is impracticable both because of the cold and the many sunless days of the winter solstice. This lack of sunshine may not only be true of the winter months, but often characterizes long periods of time during the summer solstice as well. During days of wind, damp and cloud, tubercular patients suffer very greatly, and the disease progresses more rapidly.

Climatically Arizona very nearly fulfils these conditions, and, therefore, offers the very best conditions for patients suffering from tuberculosis. The territory is largely an extensive plateau, hundreds of miles from any large body of water, situated between the two greatest ranges of the Rocky Mountains, traversed by mountain ranges and surrounded for several hundreds of miles on every side by sandy deserts. The even temperature and dryness are Arizona's chief claim to merit. The dryness means sunshine —the humidity in the air as reported by the U. S. Weather Bureau at Phœnix was on several occasions in July, 1900, as low as 1%. There is the greatest percentage of sunshine at Phœnix, Arizona, reported by any U. S. Weather Bureau office. In November of 1900 the average daily sunshine for that month was 9 hours, 12 minutes. Davos Platz, prominent in Europe for its sunshine, had but 4 hours and 12 minutes average for the same month. A very noticeable effect of the dry air is the great diminution in the amount of sputum in those cases in which there is excessive bronchial catarrh associated with the tubercular lesion.

This is an atmosphere comparable in temperature, dryness and radiancy to that of an electric arc bath, as was pointed out by the author in 1898,[1] who likened the conditions of the arc light bath to those of a clear dry sunlit day, and these are essential features of a climate for tuberculosis which it would be well to imitate artificially whenever possible.

In an electric arc bath there are no elements of depression, as in exposure to hot air, for it is not a heat bath. It is only gently warmed, and from it there is obtained a sensation of life and vitality. The chemical activities, which are cold, alone act upon tubercular lesions. This is proven by actual clinical observations, not only in tubercular diseases of the skin, but in tuberculosis pulmonalis, thereby showing that they are the effective rates of the vibrational activity

[1]The Electric Arc Bath, Am. E. T., Sept., 1898.

or frequencies of light energy. By cold light must always be understood the frequencies of intense chemical activity,—blue, indigo, violet and ultra-violet. In a complex of all the frequencies of the electric arc, also in the ionization of the air by its action and the production of its gases, the author believes that there is to be had a physical condition comparable to sunlight and fresh air. Its use cannot be continued over indefinite periods of time, nor for that matter can the same class of cases be exposed indefinitely to the action of sunlight. Care must be taken in both instances. An exposure to sunlight, and likewise to an arc light, means an expenditure of energy within the tissues, and no mechanism, whether the living organism or a high frequency transformer, for example, can take care of more energy, transform it in other words, than it is built or wound for. If there is too great an expenditure of light energies, either from too intense exposures or over too prolonged periods of time, the organism will suffer.

The opinion appears to be widespread that to use light therapeutically demands expensive apparatus, prolonged exposures, a large staff of nurses and great expense. Willard places the expense of operating a Finsen apparatus at $3,000 a year, and in the expense finds an objection to the use of light in the treatment of tuberculosis of bones and joints. In other words, the popular impression seems to be that an equipment which excludes all the energies of the arc, save the short and high frequency rates of the chemical end of the spectrum, especially a source very rich in ultra-violet frequencies, is called for.

The prominence given to phototherapy by the brilliant work of Finsen, in lupus vulgaris especially, is no doubt largely responsible for this opinion. But it does not necessarily follow that even in the treatment of lupus vulgaris and other skin lesions, so expensive an outfit initially, nor such tremendous consumption of current is necessary.

A clinical experience with light as a therapeutic measure since 1893, has demonstrated to the writer's satisfaction that

such is not the case in general conditions where applications of light diffused in a cabinet is desired, or in the case of strictly local lesions where concentrated and condensed intensely chemical light energy is indicated.

The value of sunshine in the treatment of tuberculosis, whether of the lungs, bones, joints or glands, and also in bronchitis, asthma, convalescence from grippe and bronchopneumonia, for example, is recognized and utilized just so far as is possible in combating such conditions.

In the electric bath there is to be had all the radiant energy characteristic of sunshine, not only in a more concentrated, and, therefore, more active form, but a spectrum richer in ultra-violet frequencies than sunlight because of the absorption of these in transit from the sun. It is also a source of radiant energy which is available at all times, no matter what the weather conditions.

In the crowded cities where the greatest need exists for radiant energy to meet the needs of tuberculous patients, the electric arc is always available, not only at all seasons, but at all hours of the day or night. Cabinets for this purpose cannot only be equipped but operated at a reasonable expense, and from their use an expenditure of energy similar in physical character to an expenditure of energy of solar light be obtained.

The inhibitory power of sunlight upon the growth of tubercle bacilli was established some years ago. The same is true of electric light. In the laboratory this inhibitory action of electric light is much more powerful than that of sunlight, and in the especially equipped rooms or cabinets in a physician's office this is equally true. The claim is made that this is not true of electric light in practice. No doubt under the latter conditions it is influenced by the arrangement of mechanisms for light administration, the ampèrage, and the method of their employment. This in no sense refers to a destructive action upon the bacilli within the tissues.

With the author, Freund believes that for an effect upon the deeper tissues longer and slower frequencies than the

ultra-violet rays are necessary. Laboratory experiments with the chemically active light energy are made upon plate cultures. In practice, the conditions are different. The bacilli are located deep in the tissues, and the ultra-violet rays must first pass through a relatively thick absorbing layer before they reach the bacteria. To secure such an effect, the intensity of the ultra-violet rays must be very great, the exposure very long, and it is quite within belief that the superficial layers of the skin would be severely injured. The work of Bernard and Morgan[1] seems to have established very conclusively that in bactericidal effect upon plate cultures as well as on the power to excite tissue reaction, the ultra-violet frequencies are the active ones.

That other elements of concentrated light, of larger wave lengths, that is, longer, slower and of greater amplitude, greater penetrancy, and which exert no such injurious effect upon the tissues, have a curative effect is not only easy of belief, and capable of rational demonstration, but has been established clinically.

In such conditions as tuberculosis pulmonalis for example, the indications are not only to be met by an application of concentrated light energy over the lung lesion, but the impoverished blood must be fed, nutrition must be improved and the vital resistance increased. To this end it is necessary that the entire organism should be subjected to the action of light energy. Therefore it is not necessary to concentrate and condense the chemically active energy as in the treatment of a lupus patch or nodule. The indications are best met by distributing all the energy uniformly in the rooms or the cabinets arranged for this purpose and exposing the entire body to all of the energy of the electric arc spectrum just as in the case of a sun bath. In the latter it is recognized that the effective energy is a complex of the frequencies of the solar spectrum. In this way, the more intense chemically active frequencies are able to exercise their

[1]The Physical Factors in Phototherapy. J. E. Bernard and H. de R. Morgan. British Med. Journal, Nov. 14, 1903.

especial function or rôle in the maintenance of health, or in combating disease in common with the remaining energy of the spectrum without any danger of untoward skin effects such as would obtain from the same energy when concentrated and condensed.

The indication here is not for a light energy capable of exciting superficial tissue reaction, but for a light energy of great penetrancy capable of the most profound action upon the blood in order that its normal function as the great oxidizer may be accentuated.

To this end the visible frequencies of great chemical energy, the blue, indigo and violet, are needed, but it has always been the author's practice to use the entire energy of the arc. The function of the former is therefore shared by the latter, but the mass of experimental and clinical evidence as well as the absorption spectrum of oxyhæmoglobin point to the former as the fundamentally active frequencies upon the blood.

The action of light in tuberculosis is so evident that it does not even admit of discussion. A glance at its clinical history, at the factors that favor its development and the climatical conditions favorable to either recovery or improvement, bears out the imperative necessity for light energy in this disease—not alone, but in conjunction with the best hygiene and sanitation, good feeding and exercise according to the individual's ability. Fresh air, sunshine, altitude according to the individual patient, but preferably high, conjoined with the above are universally recognized as of more value in combating tuberculosis than all the drugs of the materia medica.

De Renzi[1] who was one of the earliest to study the effect of sunshine on disease, undertook to answer the inquiry as regards tuberculosis by inoculating guinea pigs with tuberculous material. It is very evident from these experiments that sunshine assisted these animals materially in combat-

[1]De Renzi: Nature, 1894.

ing the infection, as the individuals cut off from the sun's rays succumbed much more quickly than those exposed to them. Some of the animals were kept in glass boxes exposed to the direct action of the sun's rays for from 5 to 6 hours daily; while others were placed in the sunshine also, but instead of glass, opaque wooden boxes were used. De Renzi found that the inoculated pigs in the glass boxes, receiving the maximum amount of sunshine, died after 24, 39, 52 and 89 days respectively, while those in the opaque wooden boxes died after 20, 25, 26 and 41 days respectively.

The action of light on tubercle bacilli without the living organism has been the subject of numerous experiments and it is well known that they die rapidly in a sunny atmosphere. Koch showed that tubercle bacilli were killed by exposure to sunlight. Later the electric arc was used for the same purpose, because of its richness in the chemical frequencies, especially the ultra-violet and was found to act even more energetically.

Drs. W. C. Mitchell and H. C. Crouch[1] of Denver, Colorado, made some experiments on tuberculosis sputum in reference to the great degree of immunity against tuberculosis enjoyed by those living at high altitudes. They deposited sputum from tuberculosis patients, as free as possible from mixed infection, on sterilized soil and exposed it to sunlight from one to 55 hours, 6 hours daily. Guinea pigs were then inoculated at varying periods. Control-pigs injected at once died in 20 days. Of those animals inoculated with sputum exposed more than 35 hours none died. Pigs inoculated with sputum exposed only for 35 hours died of tuberculosis, but from the lesions, the infection in those animals was thought to have been due to inhalation. After exposure of from one to 25 hours, the sputum killed the pigs in all but one case, by tuberculosis, that one alone dying of sepsis. None of the animals infected with sputum which had been exposed 35 hours died of tuberculosis. Opportunity

[1]Philadelphia Medical Journal, June 11, 1898.

is offered, however, in that period of time for desiccation of the sputum and infection of others. They reasoned from these experiments that the dryness of the atmosphere preventing the growth of the bacilli, as well as the sunshine, was therefore a factor in determining the good effects of the Colorado climate especially in tuberculosis; and that this was added to by the high altitude, increasing as it did the blood supply to the lungs and improving the nutrition of the patient.

Baradat[1] likewise finds that light enriches and nourishes the blood, produces a great reserve of energy, stimulates the nerve ends and vivifies the nerves; it acts upon the skin, accelerates its action and is able to renew the same. In his opinion, light attacks the bacilli directly and by its action, the condition of the tuberculosis soil is ameliorated and renewed. In the article quoted, he reports two cases that had been treated for 6 weeks; after 6 days' treatment the night sweats ceased, the cough diminished despite unfavorable weather and defective care, and the number of bacilli decreased.

Dr. Albert E. Sterne,[2] of Indianapolis, Indiana, also finds the electric arc valuable in tuberculosis. He finds its use as rational as sunlight itself and that the chemical frequencies from it possess a decomposing, but at the same time, reconstructive molecular action upon the body tissues mainly upon the blood elements. He used in addition to the great quantity of light from powerful voltaic arcs, free ozone developed from an especial ozonating apparatus, as described under alternating-current light mechanisms.

Freudenthal[3] has used electric light in tuberculosis for a number of years, having used it since 1889 in tuberculous laryngitis. In that year he first exposed the larynx to the light from an incandescent lamp of very low candle-power

[1]Zeitschr. für Tuberculose, und Heilstaettenwesen, 1903, Bd. V., Heft 1.

[2]Paper read before the Mississippi Valley Med. Ass., Kansas City, Mo., 1902.

[3]Freudenthal: N. Y. Med. Journal, July 12, 1902.

but for the purpose of transilluminining the laryngeal region as an aid to diagnosis. He was led to investigate the matter and also to continue its use by the statement of a patient for whom at first light was used as a diagnostic aid. It was then discontinued and the treatment carried on, along the usual lines. One day the patient asked why he did not use that light treatment any more, saying that she always felt better from its use. From that time he has used it uninterruptedly in this condition. In the more recent years he has used an electric arc in preference as it is the better source of light energy for tuberculosis pulmonalis and even for laryngeal troubles.

He has found that the marine searchlight mechanism (see Fig. 21) stands him in good stead. In the beginning of the treatment for some of his cases he uses the blue glass screen, shown in the same figure, to eliminate the frequencies below the blue on account of the heat. As a rule he prefers the use of all the frequencies of the arc, as pointed out by the author. He attributes some bactericidal power to the red frequencies even. That they are chemical to a degree is true, according to the nature of the body or substance upon which they fall, and it is possible that they may have some bactericidal power, although more recent work places the bactericidal rays in the middle third of the ultra-violet region. In utilizing the marine searchlight as a source of light energy, Freudenthal uses the parallel rays, and directs the patient to turn the body around in order to prevent any undue heat effect. He also keeps on hand pieces of linen on ice, with which the exposed parts are quickly washed as soon as they become hot. The distressing symptom of dysphagia from which patients with tuberculosis of the larynx suffer, has yielded to a greater or less extent from the use of light in his hands. In a case in which laryngeal stenosis had occurred, tracheotomy had been performed. Afterward upon examination it was found that the epiglottis covered almost the entire entrance of the larynx. He had also tuberculosis of both apices, though not far advanced and suffered from excruciating pains in the larynx, which no drug could relieve. As a dernier resort Freudenthal tried the electric light for him, which was the only thing that afforded him some relief. At least he was able to take some food.

In the light treatment of tuberculosis, it is not that in the intense chemical frequencies of light there is an energy capable of bactericidal effect primarily, but that there is an energy which judiciously expended tends to the active oxygenation of the blood, improved metabolism and consequent nutrition. In other words, every application within the recognized limits of the best therapeutic management of a given case increases physiologic resistance which results in the fortification of the individual for the conflict. The destruction of the enemy within the organism follows in the natural order of things in 2 ways, (1) by the improved nutrition and vital energy, and (2) by the ability of the rhythmic vibrational activity of the higher chemical frequencies to unduly agitate, shake up or worry the micro-organism until it delivers up its energy or oxygen. But it cannot be too strongly stated that the fortification of the individual is by far the most important consideration, and to that end every effort should be bent, not alone in the exhibition of light energy, but in attention to every detail of hygiene and sanitation, fresh air, suitable exercise, good nutritious food, and sunny and well ventilated rooms. No matter what the special means used to establish a cure in tuberculosis, or for that matter in any disease, no known physical law should be disregarded, nor the use of any accredited measure. But there is no class of cases where the skilful use of light energy is so imperative or of such great avail as in tuberculosis. The hygiene, sanitation, climatology, prophylaxis also of tuberculosis have come in the last years to be above criticism, but the therapeutic management, despite the use of all the accredited physical agents, will fall short of what it should be until light energy is skilfully used in its treatment, not only in institutions but private practice as well. It does not matter, from the author's point of view, that the most in-

tense chemical energy does not penetrate into the deeper structures. The very fact that they are absorbed by the first thick layers of blood vessels of the thoracic walls, for example, does not militate against their usefulness. The tiniest mountain rivulet, the merest thread of a stream in its steady onward flow toward the valley is a source of energy which helps eventually to swell the tremendous flow of water through the mountain cañon. Equally true is it that the absorption of these very refractive frequencies by the oxygen-carrying corpuscle of the superficial blood vessel imparts a stimulus, the influence of which must be felt to the uttermost extent of the circulation of the blood. In tuberculosis there is no greater necessity than for perfectly oxygenated blood. The increase of red blood corpuscles is associated with an increase of white blood corpuscles, bacilli are deprived of their energy, normal tissues are properly fed, and degenerated masses are removed through the increased leucocytosis.

The statistics of those experienced in the treatment of tuberculosis have shown that in order to obtain favorable results the patient must be secured when the disease is in the first stage or stage of infiltration. Not only the physician, but the general public as well, should recognize the necessity of the most earnest efforts when the disease is in its incipiency, and in addition to the hygiene, sanitation and climatic conditions, there should be added in every case the systematic use of the energies of (1) solar light where available, and (2) of the electric arc when the former cannot be commanded. Reliance upon the results of the sputum examination to establish the diagnosis cannot be too strongly condemned. It is unquestionably one of the potent factors leading to a paucity of favorable results. The fact of the presence of bacilli in the sputum, while technically the conclusive proof of the disease, should not be waited for before placing the patient under the best conditions from every point of view. Both the microscope and the Roentgen ray are valuable aids to the diagnosis of tuberculosis, but neither

the one nor the other can take the place of a careful and intelligent physical examination. One, two, or three negative sputum examinations are not sufficient evidence in view of physical signs, to withhold a diagnosis, and no physician should wait until the lungs break down sufficiently for the throwing off the tubercle bacilli, to establish the very best therapeusis. Were this always done, then an expenditure of light energy would hasten the recovery of every such patient. This is well illustrated in Case IV. of the 6 cases of tuberculosis reported from the author's cases.

Treatment was first instituted by the author in cases of tuberculosis in the spring of 1895 by means of the electric arc.[1]

The patient was placed in the arc cabinet previously described, exposing at first the anterior surface of the body.

By changing the position and lying with the posterior part of the body uppermost every square inch of skin surface was exposed to all the radiant energies of the arc, and at the same time to the gases given off by it, which exert a favorable influence. A part of these cases were treated at the author's clinic (The New York Electro-Therapeutic Clinic and Dispensary), and a part in the private office. At the former alternating-current arcs were used, at the latter direct-current arcs. The results obtained indicated that the one was as good as the other. Under the physics of the electric arc it has been stated that theoretically alternating-current arcs should give off more ozone, as it is supposed that such ozone as is given off by an electric arc is due to the breaking of the arc, and by reason of the alternating E. M. F. there is a constant make and break of the arc, i.e., at every change of sign.

These exposures were made to the entire nude body for from 25 to 45 minutes daily in private practice, and later

[1]Transactions of the American Electro-Therapeutic Association, 1898, New York Med. Journal, Jan. 28 and Feb. 4, 1899: "The Electric Arc Bath," by Margaret A. Cleaves, M.D.

on, as the case progressed, less frequently. In clinical practice 3 treatments per week were given on the regular clinic days. There was invariably secured by this light bath, diminution of cough and expectoration, freer respiration with increased respiratory capacity and quickened circulation. Its use was always followed by a sense of well being and a general appearance of refreshment. Improvement was the rule in every case, lasting in the incurable cases for varying periods of time. A laryngeal ulcer in an advanced case of phthisis, which had defied every effort of skilled specialists, promptly healed in 2 weeks' time without any local application whatever, even of the light energy, while all the symptoms were ameliorated, and marked nutritional gain established. See Case II.

Acute Phthsis.—E. M., a man aged 28 years; married; carpenter. January 23, 1897.

Patient presented himself because of cough, with pain in chest, following a malarial attack last summer. Now has constant cough, muco-purulent expectoration, night sweats, cachexia.

Inspection: Skin pale and white; emaciated; clavicle and ribs conspicuous; retraction of chest walls, with impairment of motion in infraclavicular spaces; heart beat in normal position accelerated.

Palpation: Vocal fremitus increased at right apex.

Percussion: Marked dulness over right apex, extending to fifth interspace.

Auscultation: Broncho-vesicular breathing, sibilant and subcrepitant râles over right apex. Increase of vocal sounds. On left side very harsh inspiration and broncho-vesicular expiration. Pulse, 100; temperature, 100.2°; weight, 121¾.

Treatment: Electric-arc bath; exposure from 20 to 30 minutes; temperature of bath, 90° F. Five treatments given, extending over a period of 2 weeks. At second visit "more life and energy and felt like getting around," before "felt like sitting about"; appetite better; cough diminished. At time of the third visit, further diminution in cough; sputum

less purulent. At the fourth visit cough was much diminished, strength increased, a sense of well-being present.

Improvement maintained; no night sweats while under care, save night following first treatment; improved color; gain in weight, 2½ pounds. The patient through whom he came to the clinic reported, 2 weeks later, continued improvement, and that he had gone to work again. Subsequent history not known. Two specimens of sputum were secured and examined, but the bacillus tuberculosis was not found. Examination not regarded as conclusive.

Chronic Phthisis.—J. B., a man aged 40 years; married; plate printer. December 28, 1897.

Has worked in a plating factory (bronze) for 8 years. Onset sudden; began to cough and expectorate muco-purulent matter November 1, 1891. Condition has persisted for past 6 years; morning cough and almost daily expectoration. For past 7 months dyspnœa on exertion; evening temperature. Under medical care for 5 years; thinks he is no worse than one year ago, save increased dyspnœa. Has had 3 tubercular ulcers (laryngeal); 2 disappeared under treatment, third remains. No history of consumption in the family.

Physical Examination.—Inspection: Emaciated; waxen skin; marked dyspnœa; incessant cough; impairment of motion in intraclavicular spaces; clavicles conspicuous; heart beat accelerated; respirations more frequent than normal.

Palpation: Skin warm and dry; increased vocal fremitus both upper lobes, especially right.

Percussion: Marked dulness upper lobe, right, less marked on left.

Auscultation: Increased vocal fremitus both upper lobes; cavernous breathing on right; subcrepitant râle right lower lobe posteriorly; friction râle on left, low down.

Examination of Sputum: Bacillus tuberculosis found.

Treatment: Electric arc bath; exposure 35 minutes; temperature, 90° F.

Twenty treatments given, extending over a period of 7½ weeks. At first visit, incessant cough from time of entering clinic room up to going into bath. Just before conclusion of bath marked moisture of palms, hands and forehead observed.

Sensation of bath pleasant; coughed but once during its continuance, and but once for 25 minutes afterward. Two days later, at second visit, stated that he had coughed less since treatment than during the same time for 2 months previous.

At conclusion of second treatment hands and forehead moist as before; no cough; freer and easier respiration during bath.

At the third visit reported less dyspnœa. At the fourth visit, January 6, 1898, no cough night of previous treatment, January 4; once night of 5th; not at all during day of 6th. Rate of respiration diminished from 40 before first treatment to 30.

At the fifth visit, 11 days after coming under care, dyspnœa diminished; able to walk several blocks without getting out of breath.

Expectoration of a saltish taste instead of sweetish as before, more nearly normal in color, contained less purulent matter.

At the sixth visit, 2 weeks from beginning of treatment, had an irritative cough, with discharge from posterior nares. Walked 10 blocks 2 days previously; dyspnœa slight; expectoration decreased; color of skin improved; sleeping better; no cough while at clinic, an hour and a half; laryngeal ulcer healed; throat much less anæmic. Throat examined January 10 at Throat Clinic, New York Polyclinic, healing of ulcer also noted.

At the first 6 visits the electric arc bath alone was used. Beginning on the seventh, and for the remaining 14 treatments it was followed by the static electricity, positive insulation, convective discharge with crown electrode, 10 minutes, and with brush electrode, to entire general surface

(nutritional) localized to chest walls front and back (lungs), 5 minutes.

During seventh bath no cough. Three and a half weeks after coming under care increased strength; brighter facies; better color; eyes not so preternaturally bright. Improvement continued, characterized by diminished cough, expectoration, improved appetite and sleep. On January 18, nasal and throat examination revealed hypertrophic rhinitis and pharyngitis. For this 2 applications of intranasal cupric electrolysis were made at intervals of 9 days. About the first of February for a day or two appetite not good; cough slightly increased. Sputum examined on admission to clinic 2 weeks later, and again at end of 4 weeks; bacillus tuberculosis found in every instance; fewer in the field at last examination.

At no time while under treatment did patient have special nursing, and exceptionally sufficiently nourishing food. This was especially true during the month of February. February 22 admission was obtained to St. Luke's Hospital in order that he might have care and nutritious food during the trying weather of the spring months. For the first 11 days gained 5 pounds, which he lost in the next 10 days. Three weeks after entering hospital complained of sore throat. Examination revealed 2 tubercular ulcers on laryngeal cartilages. In the hospital until April 1; unable to swallow food; discharged April 1, 1898. Returned to clinic April 7, 1898. Emaciated; extreme pallor; dyspnœa, and exhaustion. No physical examination made because of the patient's great exhaustion, but the following treatment was given: Static electricity, positive insulation, convective discharge, chain in hands, with crown electrode 15 minutes, and with brush electrode to the entire general surface (nutritional), localized to the chest walls, front and back (lungs), and over laryngeal region (ulcers), 10 minutes.

Patient felt brighter and stronger after treatment, dyspnœa lessened, improved circulation, return of color to face, able to get downstairs more comfortably. The query

naturally rises, might not the improvement established have maintained itself if the patient could have had continued treatment while in the hospital, where food and care were provided? It is impossible to answer the question now, but it seems reasonable to believe that under proper conditions the continuance of the treatment would have led to better and more permanent results. This patient was living a month since (about August 7) and up and about. Owing to change of residence cannot ascertain his condition at this writing. For several years he had been given creosote, nor was it discontinued when he came under care, on account of his desperate condition. The relief obtained, however, was coincident with the establishment of his treatment by means of the electric bath, and progressive under its use.

Acute Phthisis.—B. B., a woman aged 35 years, single; seamstress. January 4, 1898.

Patient had la grippe 5 or 6 years ago; pleurisy 4 years ago, and since then when she takes cold suffers pain in breathing, left side. In May, 1897, contracted a severe cold; tired; pains all over body; knees, ankles, and hands stiff; in hospital 8 days; improved. Has not been fully well since; now pain and stiffness in shouders, arms, fingers, and feet; badly nourished; constipated. For malnutrition and rheumatism the following treatment was given: Static electricity, negative insulation, disruptive discharge, sparks long, clean and percussive to entire general surface (nutritional), localized to affected joints (pain and disability), and to lumbar and sacral plexuses, hepatic area and abdominal walls (constipation). Eighteen treatments were given, extending over a period of 4 months, establishing marked nutritional gain, with great relief from pain and stiffness and constipation.

Patient discontinued regular attendance April 2, 1898.

On April 16, 1898, returned, complaining of sore feeling through chest, with muco-purulent expectoration. Usual treatment given, but could not remain for physical examination.

May 3, 1898.—Physical examination: Congestion of right lower lobe, difficult breathing; hard, dry cough, scant expectoration.

Treatment: Electric arc bath; exposure 30 minutes; temperature of bath, 90°F. Nine treatments given, covering a period of 5 weeks. Following first treatment respiration freer and easier; appearance brighter. May 5, sputum examined, bacillus tuberculosis found. At the second visit looked much brighter, less worn, no sense of oppression in breathing since last treatment, cough looser. Physical examination made at time of fourth treatment showed sibilant and sonorous râles, and elicited the fact of moderate expectoration. After fifth treatment patient felt stronger; coughed less. Continued improvement characterized by increased strength; more energy; diminished cough and expectoration, freer respiration. Clinic closed June 11 for summer holidays, therefore further treatment could not be given. Arrangements were made to send patient to the country under the auspices of an association for the relief of working girls, the subjects of tubercular troubles. Overfatigue and exposure to night air incident upon her going for the necessary physical examination by the physician of the association brought on an exacerbation of her trouble, and she did not leave the city until July 30. On August 16 reported by letter from Franklin County, New York, that she had gained 3 pounds, and was much better.

Acute Phthisis.—M. E. L., married. Came for consultation March 31, 1898. Family history good; no consumption; patient had systematically overworked in the active care of a large business concern; general health poor for several years; worse for a year past.

In the spring of 1897 began to cough, lost strength and flesh. In the same summer took a sea voyage and was absent from his business several weeks. Nutrition improved and cough diminished during this time, but soon after his return took cold, cough returned with loss of flesh and strength and increasing nerve irritability. In September he

was seen by his physician and examined also by Dr. Delafield. Trouble was found at the apex of the right lung, and bacilli in the sputum. Dr. Delafield told him he must give up his business and go elsewhere in order that he might be under suitable climatic conditions. The patient was very much averse to this, and decided that rather than give up his business interests and go away he would work as long as he could in order that he might provide in the best possible manner for his family and accept the inevitable when it came.

He did nothing during the winter and early spring, save to take cod-liver oil and hypophosphites. At the time he came under care, March 31, 1898, he was a good deal worn; nervously irritable; had lost and was still losing flesh; coughed a good deal, especially in the morning and at night; wakened by cough between 4 and 5 in the morning; expectoration muco-purulent; appetite poor and sleep broken.

Physical Examination.—Inspection: Patient fairly well nourished. Clavicles and ribs somewhat conspicuous.

Palpation: No change in tactile fremitus.

Percussion: Slight dulness over upper lobe on right, front, and back. Note normal on left, front and back.

Auscultation: Subcrepitant râles above and below clavicle on right over area of upper lobe. Voice and breathing slightly bronchial; increased vocal fremitus.

Examination of Sputum: Bacillus tuberculosis found.

In answer to his question as to whether anything could be done for him, the remedial value of sunshine, whether natural or artificial, and the function of electricity to improve and to restore nutrition were briefly outlined, and the improvement of several cases of phthisis under the influence of the electric arc bath detailed.

He decided to place himself under care, and treatment was instituted on the same day. For the first 14 days treatments were given daily, with the exception of the intervening Sundays.

Treatment consisted of the electric arc bath; temperature of bath, 90°F., exposure varying from 30 minutes to an hour. There was an immediate diminution of the cough, with gradually diminishing expectoration. Improved appetite and sleep, and marked lessening of nerve irritability. At the end of the first week of treatment the patient had gained 3 pounds; cough was markedly diminished; sleep and appetite improved. Improvement continued, and 2 weeks from the day he came under care physical examination was negative, save for a slight increase of vocal resonance at the apex of the right lung. In an examination of the sputum 2 weeks and 3 days from the time of instituting treatment no bacilli were found. The gain at that time in weight was 5 pounds. Throughout the rest of April and during May almost daily treatments were given, Sundays excepted, and an occasional week day. In one instance only was there an exposure of an hour, and that at the request of the patient, to whom the bath was most grateful, but it was followed by unusually profuse perspiration with slight exhaustion. After that time 50 minutes was not exceeded, while the average time was 45 minutes. During the month of June and the first week of July an average of from 3 to 4 treatments a week were given. At the beginning of the fourth week he was directed to secure a third specimen of sputum for examination, but at no time, either in the night or morning, was he able to secure anything, though he carried a bottle in his pocket for this purpose for the following 2 weeks. There was absolutely no cough or expectoration. Improvement in appetite and sleep continued, with a further increase in weight, entire disappearance of nerve irritability, and withal a general sense of well-being. During the month of June his business necessitated his going into a new building, which had not fully dried out, and as a result he developed malarial symptoms. He had at different times in his life suffered from chronic malaria. At that time he was given an anti-periodic, which was the first and only medicine given him while under treatment. Cod-liver oil

was not used; but as much cream was taken as he could digest.

In all 66 treatments were given, extending over a period of 3 months and 10 days. In the second week of his treatment the electric arc bath was omitted for 3 or 4 days, owing to an accident to one of the lamps which was not promptly repaired.

Following the arc-light bath the following treatment was administered: Static electricity, positive insulation, convective discharge with the crown electrode, 15 minutes, and with brush electrode to the entire general surface. At the same time a hypertrophic rhinitis with hypertrophy of the posterior turbinated bodies was treated with cupric electrolysis.

The applications were made with a thin copper electrode having concavo-convex surfaces, by means of which an accurate localization of the oxychloride of copper was made directly over the turbinated bodies. Before instituting nasal treatment there was difficulty in breathing, with profuse post-nasal dropping and constant hoarseness. These symptoms were of several years' standing. In addition to the nasal treatment a slow interruption of the induced current regulated to the patient's toleration was used by percutaneous applications to the throat, i.e., from side to side for 5 minutes, and from nape to larynx for 5 minutes, daily. As a result of nasal treatment nasal respiration became absolutely free, and post-nasal dropping stopped entirely.

The throat became very much stronger under the use of the induced current, with gradual disappearance of the hoarseness, which returned but once while under care, when, owing to a sudden change one late afternoon from the extreme heat prevailing, he took cold. He came to the office the following morning with an acute laryngitis, exceedingly hoarse, with almost a whispering voice. The usual treatment was given: Electric arc bath, followed by convective discharge, and the application of the induced current to the throat.

He left the office at conclusion of treatment with practically a normal voice, and maintained his improvement.

His total gain in weight up to the end of the first week in July was 8 pounds. He is a man of very slight build. He attended his business every day, not losing an hour, save the hour spent in the office for the purpose of treatment. A note on the 6th of July, stating his inability to keep an appointment, ends with the remark, "Feeling fine." On the 9th of July, writing in reference to being away for his vacation, he stated that he was very well.

This patient has been given to understand that the maintenance of his improvement depends very largely upon himself, that every attention must be paid to all matters of hygiene, and that he must have outdoor exercise and sunshine. Realizing fully the nature of tuberculosis, it follows that if at any time his nutrition falls below par the bacilli are apt to become active and the trouble develop anew.

The positive results obtained in this case as well as the improvement obtained in cases of much longer standing are, to say the least, suggestive. Five years later patient remained well and continued in charge of his business.

Acute Phthisis.—M. T., a woman, aged 28 years, single; importer. July 9, 1898.

Father died of pneumonia; mother has chronic malaria; one brother died at age of 6 with "brain trouble." Patient not strong and always nervous as a child. Menstruated at age of 12, usually pain for 24 hours before flow, duration 4 days, amount normal. Has occupied her present position for 8 or 9 years, and has overworked; meals irregular; for past 4 years much mental worry. Life indoors most of the time. Four years ago last February began to go to Paris twice a year to buy goods, since that time less strong; for 3 years tired all the time; unable to get rested; very nervous and has lost flesh during last 2 years. Last February took cold, nose and throat first, finally lungs.

Since then has had a cough, especially on retiring and rising; at intervals muco-purulent expectoration. Every 2

weeks since has had an attack of coryza with incessant sneezing and nasal discharge; malaise and great fatigue. At time of coming under care, morning and evening cough, worse in morning, wakens her, mucous expectoration, at times muco-purulent. Bowels constipated, micturition frequent. July 13, 1898, examination of sputum and Bacillus tuberculosis found.

Physical Examination.—Inspection: Patient poorly nourished; retraction of chest walls above and below clavicles, especially on right; skin inactive, pigmented in defined areas over sternum.

Palpation: Vocal tactile fremitus normal.

Percussion: Percussion note, anteriorly and posteriorly over upper lobe of right lung is of higher pitch and of shorter duration than normal. Note over left chest normal.

Auscultation: Vocal resonance increased over upper lobe on right; subcrepitant râles below right clavicle; diminished breathing. Left side anteriorly sounds normal: posteriorly infrascapular region loud sonorous râles.

July 25, 1898.—Sputum examined and Bacillus tuberculosis found.

Treatment: Electric arc bath; exposure 20 minutes to an hour. The shorter exposure was given on the hottest days. Free perspiration always established with improved color and rested appearance. At the end of the first 5 days cough markedly diminished both night and morning, expectoration decreased. For the first 8 days treatment given daily except on Sunday; during the 2 weeks following treatment was administered daily with one exception, while the last week but 3 treatments were given.

August 5, 1898. Physical examination: Skin of better color, less dry and harsh; respiration freer; volume increased.

Subcrepitant râles; no sibilant or sonorous râles. Percussion note improved. Sputum examined and Bacillus tuberculosis found.

At intervals of 5 days 3 applications of cupric electrolysis

made to hypertrophied turbinated body, inferior left, 5 milliampères, 3 minutes each. At the end of 2 weeks, in spite of the heat of the summer weather and continued application to business, there was a gain of one pound: improved appetite and sleep; general sense of well-being; no cough at night, rarely in the morning; scarcely any expectoration, save from the throat. Menstruation established August 1, free from pain, very comfortable. Is to sail for Europe to-morrow, August 6, to be gone 5 weeks. This patient remained well when last heard of some 5 years after coming under care and able to attend to her business.

Case VI.—J. G., male, aged 20 years; shipping clerk. August 19, 1898. Father dead; mother living and well; one sister, one brother, both well. For the last 2 or 3 years not well, chronic malaria. Began to run down in April last, and had a severe hæmorrhage, pulmonary, at that time. Went to the country, absent until July 4. No hæmorrhage during absence. Made some gain. Since return has steadily lost flesh, troublesome cough, with expectoration; sense of malaise; poor appetite. In July had a very severe hæmorrhage, lost a good deal of blood from which he has not recovered. On July 31 consulted Dr. C. O. Maisch, instructor in diseases of children, New York Post-graduate Medical School and Hospital, who reports the following:

"Slight dulness over left apex, anterior more marked; accentuated breathing. Vocal fremitus slightly increased, no râles. Right lung over apex a few sibilant râles, respiration over both lungs very much restricted. Retraction of intercostales and some dyspnœa always present. Expectoration moderate, cough not very troublesome. Hæmoptysis; anorexia; malaise weakness; emaciation progressive. Sputum contains a very few tubercle bacilli. Temperature, 100.2°; pulse, 110.

"August 12.—Physical examination: Over left apex dulness to within an inch of inferior angle of scapula, and over this area there is marked increase of vocal fremitus; bronchial and tubercular breathing; crepitant and subscrepi-

tant râles; moist mucous râles over the entire surface indicated. Right lung unaffected. General condition much worse. Temperature, 101.5°; pulse, 120; cough troublesome and expectoration considerable.

"August 20.—Patient in same condition; complains a great deal of weakness."

This patient was referred to the writer for treatment August 19, 1898. Physical examination was not made nor treatment instituted until August 20. At that time patient presented appearance of a very ill person, loss of flesh, great difficulty in breathing, rise of temperature, evening and morning cough most marked, occasionally during day, moderate expectoration, poor appetite, regular bowels, malaise, great weakness, and walked with difficulty, even a few steps.

Physical Examination.—Inspection: Patient much emaciated, anæmic; chest walls retracted; left chest flattened, with impaired motion.

Palpation: Marked increase of vocal tactile fremitus over left chest anteriorly.

Percussion: Marked dulness over upper half left lung anteriorly and posteriorly.

Auscultation: Crepitant and subcrepitant râles over area of dulness on left; vocal fremitus markedly increased; harsh breathing. Right side normal.

Patient very weak and obliged to sit several times during the examination.

Treatment: Electric arc bath; exposure 20 to 30 minutes; temperature, 90°F.; followed by static electricity, positive insulation, convective discharge with the crown electrode for 15 minutes, and with brush electrode to entire general surface (nutritional) localized to chest walls front and back (lungs) for 5 minutes. Afterward sat upon the platform for 5 to 10 minutes daily with ground connection removed and discharging rods within sparking distance of one another. During this time directed to breathe deeply and steadily of the ozonized atmosphere.

Daily treatments given up to August 27, excepting the intervening Sunday, and save in two instances the exposure lasted for half an hour. From the beginning of treatment there was a marked lessening of dyspnœa, increasing respiratory capacity, slight diminution in cough, with, as a rule, less expectoration.

On August 25 appeared very much better; facies brighter; respiration freer; coughing only in the morning, and less than before; taking sufficient food, but without special appetite; lowered temperature and diminished pulse rate; able to walk 5 or 6 blocks without much effort. On the 26th and 27th had rather a sharp attack of diarrhœa, which caused considerable weakness. From August 19 the weather was excessively hot, with great humidity, and as patient's home was a single room in a tenement house in the most crowded portion of the city, he was unable to get much rest at night.

On August 27 referred back to Dr. Maisch for examination with the following result: Temperature, 99°F.; pulse, 115; general condition of patient improved; dyspnœa less troublesome (very much); cough less. Lungs: Left apex, dulness as before, has not extended. Rhonchi seemed fewer in number, and would indicate that liquefaction was not so great as at last examination. Right lung not affected. Moderate diarrhœa. To patient, physician stated, "You are very much better." Treatment: August 29 as before. Slight diarrhœa; coughing but little, and in morning only; raising less than before. In answer to an inquiry as to why the patient did not return for treatment, the following letter is quoted:

"223-225 E. One Hundred and Seventy-sixth St.,
"New York City, September 7, 1893.

"Dear Dr. Cleaves: Yours of the 2d inst. in reference to J. G. received. I had heard nothing of him, and so looked him up yesterday at his home in Baxter Street. He has been in bed some days. I found him with temperature

104°F., pulse 120, and in pretty bad condition. He has an acute pleurisy on the left side anteriorly. The physical signs in the chest have not changed since I saw him, except that he has developed a diffuse bronchitis, involving both sides. His general condition is worse; his surroundings are bad, and the hygienic conditions hopeless. He has had no hæmorrhage. Should he get up again he will come to you.

Yours,

"C. O. M."

Summary: Of the cases reported, all save 2 were dispensary patients, for whom there could be neither change of environment nor dietary; 2 were incurable, and yet there was a modification of all the symptoms, with, in one case, healing of a chronic tubercular ulcer of the larynx in 2 weeks' time and with but 5 exposures. The author has no thought that in light energy, whether solar or the electric arc, a panacea for tuberculosis is to be found—far from it; but the uniform results obtained in the preceding series of cases, which were very carefully studied, as well as in the practice of others.

In a case of pulmonary tuberculosis reported by Sciascia, the duration was only 2 months, and while the physical signs were not positive, the tuberculin test evoked a decided reaction. The symptoms of the disease began to subside in 40 days, and 20 more applications resulted in recovery. Seven years later the patient remained well. Sciascia is of the opinion that the treatment would be of value in the pre-tuberculous stage, but that later it can only strengthen the natural forces, and diminish the tendency for the disease to spread. In this the author concurs.

Freudenthal, Kime, Foveau de Courmelles, and others regard light energy as of very great value in curative cases of tuberculosis.

The results of Kime with concentrated solar energy (see Chapter XI.) are corroborative of the author's experience with electric arc light energy. Similar results have since been

obtained by Doumer and Finsen, and in this country 1901-1902, by Hopkins. More recently M. Foveau de Courmelles has had the same clinical experience with pulmonary tuberculosis and has also treated tubercular glands, fistula, and joints with good results. It is well established that short and high frequencies or chemically active energy are the curative frequencies. In most pathologies other than those of the skin, all the radiant energy of the arc is of value.

Tuberculosis of the Bowels.—In a case referred to the author with a diagnosis of tuberculosis of the bowels, woman aged 32, presenting the classic clinical picture, impaired appetite and digestion, especially intestinal, attacks of diarrhœa, emaciation, hard rigid abdomen; there was obtained from the first exposures in the electric arc bath a softening of the abdominal walls, with disappearance of rigidity. This was followed, as the treatment progressed, by improved appetite, increased digestive power, cessation of the diarrhœal attacks, lessened anæmia, increased weight, all pointing to the general nutritional gain. The patient had had pulmonary complications, and at one time bacilli in the sputum. The cough, expectoration and bacilli had disappeared from a long residence in Colorado, but the intestinal complication had not yielded to any form of medication, diet or to the climatic change. This patient made a good recovery, although never strong nor robust, and when last heard from 2 years after treatment remained well. The entire nude body was exposed to the action of the light in the electric arc cabinet described, for from 25 to 45 minutes at first daily, and then every other day. It was followed by the use of the convective discharge of static electricity with crown, and to the entire general surface. The patient was under care 2 months.

In a historic sketch of some of the so-called cures for pulmonary tuberculosis, J. E. Stubbert[1] presents a few notes on latter-day treatment. The various therapeutic methods

[1]Medical News, April 9, 1904.

in vogue to-day, including drugs, light, electricity, water, serum, intravenous and subcutaneous injections, etc., are all considered. In the light of present knowledge, diet, hygiene and fresh air are universally accepted as the foundation of all scientific treatment. Upon indication they must be supplemented by symptomatic treatment in the way of antiseptics, tonics and surgical interference. The probability Stubbert believes is that within 3 years notable advances in immunization, and the stimulating effect of light will be seen. Strebel states that the good influence of electric light on the strength and nutrition of the tuberculous, if not too much reduced and debilitated, seems, according to his experience, incontestable. It is well in this connection to recall the experiments of Bergel upon ciliated corpuscles. Upon exposure of a ciliated corpuscle that had been in the dark and was inactive, to the action of light it commenced to oscillate again. In tubercular cases the ciliated corpuscles are inactive because the bronchi are filled with a quantity of secretion. These corpuscles require an extraordinary stimulus in order to take on their movement again. This stimulus is imparted by the light energy of the arc, also by that of sunlight. In both instances the chemically active blue, indigo and violet frequencies, which are very penetrant, *penetrate the deepest* bronchioli, and exercise a direct influence upon the ciliated epithelia. From the stimulus of light energy they resume their oscillatory movement, in other words, they take on their function and the secretions are carried to the upper parts of the bronchial tract, from which they can be removed by expectoration. This physical explanation of the action of light energy in rendering expectoration less difficult is the one made by Freudenthal. In this connection he states, "I remember one patient who was driven to my office daily up to 2 days before her death in spite of high fever and other distressing symptoms, as she always felt so much easier after exposure to the electric light. She could expectorate better and had less pain and less fever. In incipient cases you may bring about a cure

by these means. I believe that some of my cases have been cured in that way, but in advanced tuberculosis electric light is only a palliative measure of occasionally great value."

Freudenthal[1] reports the following cases:

Case I.—A. R., 24 years of age, a drummer, came to me September 6, 1900. He had been well up to a week before, when he caught a severe cold. Since that time he had had intense pain in the throat, more so at night; could not swallow food, although he was hungry. He admitted he might have had a slight rheumatic attack before. The examination showed an acute left tonsilitis and ulceration in the left pharyngeal fossa, both of which were attributed to rheumatism. In a few days the ulcer disappeared under salicylate of sodium and local astringents, and so did to some degree the pain. But very soon he felt it again, "farther up." The left tonsil was more swollen and sensitive to the touch.

Sept. 10.—Tonsil more swollen, no abscess; œdema of the uvula and neighboring parts on the left side. Severe pain. Electric light was applied for 45 minutes to the left side of the throat, with the result that for the first time in 2 weeks the patient slept well.

Sept. 11.—Oedema has disappeared, the tonsil is much less swollen and much less sensitive, and he feels comfortable.

Sept. 20.—Says he does not regain his strength. Has some pain over the chest. On examination, some râles were found over the left clavicle anteriorly, bronchial expiration and tubercle bacilli in the sputum. He was treated daily with electric light for about 5 weeks, when all the symptoms had disappeared. He went back to business, and has been in good health since.

In this case the effect of the electric light application to the tonsil and uvula was simply remarkable, and the patient was most grateful. The primary conditions, however, were

[1] N. Y. Med. Journal, July 12, 1902.

believed to be of a rheumatic nature, although the pain was very great. When, later on, tuberculosis developed the result was not so quickly obtained as in the beginning, but when obtained was extremely gratifying.

Case II.—Miss M., aged 17, hoarse for a year, coughed occasionally, had night sweats, no appetite, and often felt dizzy. She was very anæmic, which showed itself especially in the pharynx and epiglottis, while the other parts of the larynx were rather congested and partly thickened (infiltrations?). The lungs showed dulness over both clavicles, more marked on the left side, slight râles anteriorly and posteriorly, and bronchial breathing over the left clavicle. Besides, there were hypertrophies in the nose, which were removed. The sputum could not be examined, as she raised none, but there was no doubt but that the condition was that of tuberculosis. She remained in this city from April 25 to July 5, 1900, after which time she went to the mountains. The symptoms gradually disappeared, there were no râles, breathing was vesicular, there was no rise of temperature or night sweats when she was discharged. The larynx was still congested, and her appetite had improved but little. Subsequently she was reported well. In this case of incipient phthisis a "cure" was also effected, so far as a cure in such cases can be obtained, which was largely due to electric light.

Since the author's first experience with light in pulmonary tuberculosis there has been noted in all the literature of the subject, not only the same improvement but the same order of improvement in the experience of different operators which was first noticed and recorded in the writer's cases; an improvement which in curable cases resulted in recovery; in incurable cases, in a relief from distressing symptoms and increased comfort while life lasted, even to the end. Such a uniformity of experience as to the disappearance of symptoms and result would not obtain were the agent used other than potent of good. In the profound action of the chemical frequencies of light upon the blood,

especially upon the red blood corpuscle, thereby increasing its oxygenating power, is to be found sufficient and rational explanation of the action of light in tuberculosis. Especially true is this, where the naked chest walls or the entire nude body is exposed to the action of chemical light from powerful sources of light energy.

The blood which passes and repasses in a long exposure through the illumined area, absorbing the penetrating chemical frequencies, and as absorption of light energy does not take place without work being done, the result is an impartation of a stimulus or energy to the absorbing media. The extinction of energy in space or its absorption and consequent disappearance in matter is a deep-seated fact in nature. If waves of light strike a growing plant they do work; and to this end are absorbed all above the green. The red medium of the blood, with its magnitude of function, upon which life depends, cannot, according to physical laws, be an exception to the law of light absorption; a law which has been abundantly proven by experimental work and clinical observation. The absorption of light energy by the living organism is one of great import, and by it the writer believes is to be found the key to read the letters of life, just as the astro-physicist regards it as "the key to read the letters of the universe."

An exhibition of electric arc light energy has not only yielded good results at the author's hands in tuberculosis of the lungs but in all diseased condition of the respiratory mucous membrane which have offered themselves for treatment.

Among these conditions may be mentioned chronic bronchitis, bronchial asthma, convalescence from la grippe and broncho-pneumonia characterized by constant harassing cough and profound exhaustion, hay asthma and acute catarrhal colds.

In the treatment of all diseases of the respiratory system, as well as in catarrhal conditions of the nasal passages, there have been secured certain definite and invariable results: viz., improved respiration, fuller and slower, with gradually

increasing respiratory capacity; diminished irritability of the mucous membranes and lessened discharge. Improvement from the harassing cough has invariably been noted from the first exposure. In acute catarrhal colds with sneezing and coryza, exposure to the light energy of the arc uniformly results in complete control at the time of these manifestations. If the condition be taken sufficiently early its further progress is arrested.

In hay asthma a similar result is obtained. From single exposures of a half an hour to an hour, the râles over the chest and the sneezing will disappear.

It may be thought that the element of suggestion enters here. The author thinks not, for similar results though less brilliant have been obtained in cases of hay asthma from an expenditure of electrical energy (1) intra-nasal cathodal electrolysis with mild current, 5 to 10 ma., (2) the action at the anode on oxidizable metals, copper notably, 5 to 10 ma., (3) vacuum tube discharges from a static machine either with or without a transformer.

Freudenthal has also had experience with this same class of cases. He states that during the last 2 years he has treated 24 patients with hay fever. The following statement embodies his results and opinion. "Out of these 14 experienced decided improvement in all respects very soon after the treatment was commenced. In some cases the profuse discharge from the nose, sneezing and asthma were relieved right after the first exposure to light. All these fourteen patients could stay in the city and attend to their business, but of course had to come for treatment regularly. Six of these 14 were treated during 2 seasons and it seemed as if all had much weaker attacks the second time than in the previous year. The rest of the patients, 10, improved but little or left treatment too soon to form an opinion.

"The following will serve as an illustration:

"Mr. C. K., aged 35, manufacturer, came under observation September 9, 1900. A year before he was attacked for the first time by hay fever, and this year it commenced as early as August 6 at noon(!) He had all the symptoms of this disease in a very aggravated form; sneezing, running of the nose and eyes, asthma, insomnia, loss of appetite, etc. Suprarenal extract was applied to his nose and he was exposed to the light, when he professed to feel like a new man. Besides he was given hydrochloric acid to take internally, and in 2 days he went to business again. He was seen every 2 or 3 days until the beginning of October, when he had no further trouble.

"The good result in this case was so much the more remarkable as this patient had been subjected to all sorts of treatment. He even saw a very prominent consulting internist in this city, who told him nothing could be done for hay fever patients! The following year treatment was instituted on July 16, in order, if possible, to avoid a recurrence. A certain degree of success was obtained, as the symptoms were much less marked. Only from the 4th to the 7th of September he felt quite heavy. At other times he occasionally had slight sneezing and rattling in his chest, which reminded him that he was not as yet out of it entirely."

This one case may suffice for a series of others which showed similar, although not always such distinct results. Freudenthal considers himself justified in declaring the electric light treatment a very important factor in combating the symptoms of hay fever. Whether this is due merely or mostly to suggestion he does not know, but the symptoms of hay fever are so unpleasant and so annoying that we must try any remedy at our disposal to relieve them.

The Electric Arc in Bronchitis.—In a case of chronic bronchitis in the author's practice, male, age 40, habitual drinker, complicated by Bright's disease, albumen occupying one-third of the tube used for testing the urine, there was constant and harassing cough, with pink-colored sputum. Despite the fact that almost a week was spent in hard drinking during a period of 2½ weeks there was secured by the action of the light energy complete relief from the harassing cough and expectoration with for a time a

slightly improved renal condition. Some 6 months later he succumbed to the chronic nephritis. Prior to his coming under care he had not only been given the classic remedies, but he had spent some months in Asheville, N. C., and in Southern California without benefit.

The following case given in detail as a clinical guide is illustrative of the course of these cases under treatment.

Subacute Bronchitis.—F. W., a girl aged 3 years. December 3, 1896.

At the age of 16 months patient had pneumonia, at 2 years tonsilitis, and 8 months subsequently malaria, intermittent type. Two weeks prior to admission contracted a severe cold, characterized by febrile disturbance, loud breathing, moaning in sleep, pain through chest and cough at night.

Physical Examination.—Subcrepitant râles over chest anteriorly and posteriorly; crepitant râles in inferior clavicular region left; sibilant râles right.

Treatment: Electric arc bath; exposure 20 minutes; temperature of bath, 90°F.

Eight treatments given, covering a period of 6 weeks and a half. Pulse and temperature records taken before and after treatment showed that the pulse, markedly irregular before treatment, became normal in character after the first 3 treatments. It was uniformly diminished in rate and of better volume. Upon leaving the bath the skin was warm and moist and respiration freer.

At the fourth visit physical examination revealed the presence of large mucous râles, and the mother reported that the cough was looser. After the fourth treatment patient did not cough during the night. The congestion gradually disappeared, appetite and sleep improved, and respiration became normal. Patient always fell asleep in bath. Discharged recovered. No drugs given.

September 1, 1898.—No trouble since.

Nocturnal Enuresis.[1]—J. C., 21 years of age; suffering

[1]This case was first reported in 1894.

from anæmia and enuresis. The electric light bath was given for 20 minutes. The patient was placed upon a stool within the cabinet, with the entire body exposed to the rays of light, special attention being paid to localizing it over the lumbar and sacral plexuses. The treatment was entirely experimental, but with the expectation of, at least, improving the nutrition. The patient had suffered from nocturnal enuresis as far back as she could remember. Menstruation was established at 17, and was perfectly regular. All the conditions were normal, save that the patient was decidedly anæmic, and suffered from facial acne; the pupils were always dilated, and there was a tendency to constipation, the bowels often moving but once in 2 days—rarely 2 or 3 days consecutively. The wet nights were slightly variable; she would sometimes go in summer 2 or 3 nights without trouble, but rarely for this time in winter. In all, 16 treatments were given, extending over a period of $1\frac{1}{2}$ months, 3 times weekly. Careful examinations of the urine were made at first, and the pulse, temperature and skin were carefully watched. Thirteen observations were taken of the temperature and pulse. In 11 instances the pulse dropped, and it was always of better volume after the bath. In 2 instances the pulse remained unchanged but with improved volume; while in every instance (13 times) there was a rise in the temperature of from .1 to .8 degree. The skin always became moist under the application and during the last treatments perspiration was very profuse. There was a general sense of well-being expressed by the patient after each application. Soon after coming under treatment the bowels became regular, and there was no trouble during the time she was under care, not since then, a matter of nearly 6 months, excepting for a few days at one time after discontinuance of treatment, when very much hurried making preparations for leaving the city, she was slightly constipated. The urine was analyzed from time to time, and showed a steady increase in the amount of urea eliminated. The patient gained $1\frac{1}{2}$ pounds during the first 2 weeks,

and since that time has gained 7 pounds more, and is in better health than for several years. The temperature of the bath varied on different days, being affected by the outside temperature, but ranged from 90° to 100°F. The patient always left the office feeling much better. No drug of any sort was given or allowed the patient during the time she was under observation.

Eczema.—In the case of a young girl, aged 13, with chronic eczema, several years' duration, of the fingers and hands, where every finger, thumbs also were cracked and fissured, preventing piano practice or use of embroidery flosses, every crack and fissure save one healed from a single half hour exposure to the energy of the arcs in the cabinet described. So brilliant a result as this does not indicate that a single treatment is sufficient. On the contrary, for in order to secure a complete and lasting cure, it is necessary that the light energy should be expended over a period of time greater or less according to the underlying conditions.

It is only by the establishment of nutritive changes or the alteration of a dyscrasia, through normal oxygenation of the blood and metabolism, that the eczema, the expression of the one or the other, will disappear. The following case illustrates the action of light energy in the same class of cases. There was no accurate concentration of the light in either case as with the mechanisms for skin work. In fact, both cases were treated before Finsen's therapeutic work was done.

Eczema Cruris.—A. M., a woman, aged 29 years, single; dressmaker. February 18, 1896.

Presented herself because of spot on anterior surface of right leg. One year since fell and scratched her leg below the knee. Spot became red, infiltrated, itched moderately with tendency to moisture, stocking adherent; later crusts appeared on the surface.

Physical Examination.—A patch size of palm of hand below patella, color dull red; covered with crusts and exuding moisture; tissues underneath thickened and swollen.

Treatment: Continuous current, active electrode, 6 square inches in area over eczematous surface negative; indifferent electrode right foot in normal saline solution. Temperature, 100°F., 5 milliampères, 10 minutes.

Four applications were made, extending over a period of 10 days. After second treatment marked hyperæmia over upper part of patch; tissues softer, with partial loss of crusts. After third treatment several islets of healthy skin visible, fewer crusts; improved circulation. Because of general malnutrition treatment changed from local application of the continuous current to general nutritional treatment as follows: Electric arc bath; exposure 30 minutes; temperature of bath, 90°F.

Two treatments extending over a period of 16 days. Not able to come for further treatment because of a severe cold contracted from exposure going to and from her work. In May reported through a friend that the patch of eczema had entirely disappeared. No drugs given. From clinical experience with other cases of eczema treated solely by the continuous current the opinion is justified that the prompt and complete disappearance of the eczematous spot was due to the action of the electric arc. The light was focused directly by means of the adjustable reflector or silvered mirror on the spot of eczema.

Psoriasis.—No attempt has been made to treat psoriasis by means of concentrated light, but such cases as have presented themselves have been treated by means of non-concentrated arc light energy, in the author's cabinet.

The cases treated therein made prompt recoveries, and the belief is entertained that a general treatment is much more efficacious in these cases than a local treatment. Here again the psoriasis is but an expression of the systemic condition.

A young woman, aged 18, whose body was not only covered with psoriasis eruption, but who was profoundly anæmic, lost every patch and scale in 3 weeks' time, the anæmia lessened with increased hæmoglobin, and the gen-

eral condition improved from exposures varying from one-half to three-quarters of an hour every other day. This patient after a lapse of 4 years has never had a similar recurrence. When closely confined indoors, and anæmic she has seen now and then a spot or two, but at no time has the body been covered as before. The conditions of her life are not favorable to the best of health, and she has suffered from anæmia from her infancy.

Sterne also mentions having treated in his alternating-current arc both eczema and psoriasis. The following case, also from the author's case book, is equally illustrative.

Psoriasis Universalis.—H. B., a woman, aged 26 years, single; nurse. April 10, 1895.

Referred from the New York Skin and Cancer Hospital.

Physical Examination.—General eruption over body, more marked on extensor surfaces of arms and legs; red papules covered here and there with silvery white scales; no discharge; conjunctiva and gums anæmic; depressed; case has proved an obstinate one, and has not yielded to classical treatment.

Treatment: Electric arc bath; patient nude; exposure 30 minutes; temperature of bath, 90°F. Four treatments given, extending over a period of 9 days. After first bath, circulation improved, skin warm and moist; patient felt warm and comfortable and looked rested.

At second visit improved appetite and sleep with general sense of well-being. After second treatment remarked that she "felt that she had been born again." Improvement continued, characterized by nutritional gain and clearing up of the skin. Treatment suspended at end of 9 days, as patient had to leave the city. Subsequently heard from through an interne of the New York Skin and Cancer Hospital, who reported that she was entirely well. No drugs given. In this case, as well as every other reported, the patient always looked rested and refreshed upon leaving the bath, skin moist and rosy, eyes bright.

Nervous Diseases.—The rôle of light energy in the

treatment of functional nervous disorders especially, is not clearly established. That there is an action other than upon the blood, important and far-reaching as that is, seems evident. Under the biological action of light, this has been considered as fully as present experimental work, superimposed upon physical fact and physiological action justifies. The writer is of the opinion, however, that by far the most important action is upon the blood, and that by the absorption of light energy of definite frequencies, a stimulus is imparted the influence of which extends to every organ and tissue of the organism. There is undoubtedly a field of very great usefulness for the use of light in nervous disorders. In no class of functional nervous disorders is its exhibition of more avail than in neurasthenics.

It is a matter of daily observation in the author's private practice that in neurasthenic patients suffering from intense nerve irritability, exposure of the superficies of the entire nude body to the radiant energy of the arc, without the intervention of screens of colored glass for from 20 minutes to three-quarters of an hour results in lessened nerve irritability, improved circulation, and a sense of well-being formulated by them as a sense of "refreshment and repose," which is strongly at variance with their condition before treatment. In this class of patients, the sense of repose and well-being is much more marked from the effect of the arc light bath than from the usual electrical treatments. It is by reason of its nearness of physical kinship to light that high frequency currents serve to favorably influence the same class of cases. This was markedly the case of a noticeably neurasthenic patient, in whom the nerve irritability had been accentuated by reason of an exhausting menstrual flow associated with over-fatigue and anxiety, and who also suffered from great apprehension and morbid fear evidenced by her voice and mien as well as vouched for by the patient prior to treatment. An exposure of half an hour resulted in a more active circulation as evidenced by pulse and skin coloring, from absolute pallor to one of normal

coloring, in the most marked lessening of nerve irritability, the disappearance of sense of apprehension and a sense of general well-being. The improvement established by the one exposure continued until the next on the following morning. The rationale of the action necessitates, as with the expenditure of any form of physical energy, or for that matter—chemical energy in the form of drugs, repetitions of the treatment over considerable periods of time and at intervals, frequent at first but later less frequently. With the firm establishment of nutritive changes, they should be discontinued, or in some cases, a more energetic or a coarser stimulation, so to speak, may be necessary after the first few weeks, in the form of electrical treatment. The administration of tonics, nerve or circulatory, must be left to the judgment of the individual physician, and should be given if indicated, although many patients will recover without their help. Perhaps no one has given more attention to the use of light in the treatment of neurasthenia by the use of the chemical frequencies of light than Dr. Albert E. Sterne,[1] who presented an interesting paper upon the subject to the section of nervous and mental diseases, at the fifty-fourth annual session of the American Medical Association.

For the past 6 years Sterne has used the chemical frequencies of light in a considerable array of conditions, neurasthenia and debility, pulmonary tuberculosis, diabetes, syphilis, rheumatoid affections, as well as distinct organic nerve conditions, also in the many localized conditions so often encountered in neurotic subjects, notably acute and sub-acute pelvic inflammations and exudates. In the 6 years in which he has employed light therapeutically, he states that he has given an aggregate of thousands of treatments in a large number of cases, and that while there have been failures, the method has as a rule given excellent and in some instances remarkable results.

[1]Neurasthenia and Its Treatment by Actinic Rays, Journal of the American Medical Association, Feb. 20, 1904.

In the treatment of locomotor ataxia and other constitutional diseases, the results from the use of the chemical frequencies of light have been more satisfactory than any other method, and he states that he has used almost every method of any worth whatever. But in neurasthenia and other debilitated conditions, the best results have been obtained at his hands from this method. They have been almost uniformly excellent, very few if any failures occurring. And not only were the results individually good but the duration of treatment has been materially lessened, in some instances to fully one half. This he stated was very clearly evidenced from a comparison between the length of time patients remained at his sanitarium now and formerly.

Foveau de Courmelles found that in some cases facial neuralgias and cutaneous hyperæsthesias, which in general yielded to blue light, were made worse by blue light, but that they promptly yielded to the activities of the electric arc. Courmelles notes, in passing, the well-known power of the X ray to cause sudation in similar cases; also high frequency currents, all of which are similar physically and physiologically.

The author has found the action of both incandescent and arc light of value in the treatment of severe neuralgic conditions and reported in 1894,[1] relief in a neurasthenic patient, who was suffering from severe neuralgia of both cervico-occipital and supraorbital nerve distributions. The relief established at a single sitting lasting for several hours.

Dr. Julius Rosenberg[2] collates a number of cases, in reviewing his experience with phototherapy. He is of the opinion that in light a remedy of no mean order is to be had and one which in the near future will occupy a most exalted position; the possibilities of its curative action are still unknown.

[1]Report of Committee on Light as a Diagnostic and Therapeutic Measure. American Electro-Therapeutic Association, 1894, Transactions Am. E. T. Association, 1894.
[2]N. Y. Med. Journal and Phil. Med. Journal, April 23, 1904.

For a source of energy he uses a 55-ampère iron carbon arc. He regards the high ampèrage necessary and the specially prepared carbons. The divergent rays are collected by the mirrors of the apparatus, enabling him to throw and concentrate the light upon a given point. Exposures are from 55 to 75 minutes; a shorter application he regards as not of lasting benefit. In a sensitive skin the expenditure of so great an energy and one so rich chemically over so prolonged periods may produce an erythema but with ordinary care he does not find that it either produces blisters or other injuries. The treatment as a rule is not unpleasant, but indeed affords relief from any pain from which the patient may be suffering and is therefore gratifying both to patient and physician.

Rosenberg reports 20 cases as follows: Neuralgia in right breast 7 weeks' duration, usual classical treatment, recovered under 2 applications of light, duration 55 minutes. Severe neuralgic pains originating in left ovary in patient 5 months pregnant, locomotion difficult and painful, relieved entirely by 2 light treatments. Intercostal neuralgia, 4 years' duration, constant pain, varying in severity, treated by Rosenberg for years with but little relief, disappearance of pain after third treatment by light, no return after 2 months. Coccodynia, from traumatism, miserable for a year, unusual tenderness at sacro-coccygeal articulation, no abnormal condition of rectum or genitals, relieved considerably after first treatment, free from pain after 2 weeks' treatment.

Ovarian neuralgia, left for years, organ enlarged and tender. Local treatment, tampons, etc., without much relief. Patient relieved by first treatment. Apparently cured after 5 exposures; ovary smaller and no longer sensitive. Injury 5 years since, patient fell upon buttocks, since pain and tenderness in lumbar region, especially left side, very miserable last summer, spasms of erector-spinæ, producing temporary spinal curvature; massage and continuous current of no benefit, seen in consulta-

tion by nerve specialist, who advised Paquelin cautery to be applied and rest in bed. Slight improvement resulted but patient never free from pain. Pain much worse 3 weeks previous to report, considerable distortion of the spine, unable to turn in bed, as the slightest exertion caused extreme agony. Relieved by first treatment, and after 5 treatments the patient was free from pain and able to be about. The remaining 13 cases include a sciatica of several years' duration, apparently cured after 9 applications; a neuritis, musculo-spinal of 4 months' duration, all remedies tried, morphine in $\frac{1}{2}$ gr. doses gave transitory relief; completely relieved for 8 hours from first exposure and went to sleep for the first time in weeks without opiates. In all 12 exposures were made, and at time of report the patient was able to attend to business, no longer using opiates and with the exception of a slight rigidity no pain or discomfort. The remaining cases are of much the same character and were relieved with the same celerity. Two cases of tic douloureux will serve to complete a very interesting clinical report. Mrs. ——, a facial neuritis of 6 years' duration, untold agony, most of her teeth had been removed also her lower jawbone. First seen 5 weeks prior to the report, could barely speak, every movement of the jaw painful, sharp shooting pains, a typical picture of tic douloureux. The first treatment produced a wonderful change in her condition, she left the office free from pain, and a treatment every third day had kept her comfortable. She sleeps without opiates and is able to receive the much needed care of a dentist. The case was not regarded as a cure but in a few weeks, even days, results had been obtained, which years of medication and operations had failed to secure. Mrs. S. F. Tic douloureux for 10 years, division of the nerve at various points afforded either no, or only temporary relief. Applied for treatment by advice of family physician, in the greatest agony. Temporary relief from exposure to the light but pain returned with undiminished severity whenever they were removed. Treatment discontinued after the third

treatment on advice of a nerve specialist, who stated (?) "that the treatment if continued would cause burns and brain injuries."

In a boy of 10, twitching of facial muscles since infancy, the spasms had almost entirely ceased after 7 exposures, the light being directed to the occiput. Neither cure nor improvement was expected and Rosenberg states that had the boy been an older subject, the possibility of hypnotic suggestion might have been considered.

These detailed cases of Rosenberg's are corroborative of the writer's experience with the treatment of similar cases by the electric arc light energy for the past 11 years. Recently, concentrated light, deprived of all the thermal frequencies, has been used successfully (1) to relieve extreme cerebral congestion, one application 10 minutes in duration made to cervical cord with compression, (2) localized pain and soreness as a sequence of spinal hemorrhage, followed by complete paraplegia; partial recovery but incontinence of urine, one application 10 minutes in duration and (3) in a case of severe neuralgia involving all the nerves of right side of neck, face and occiput secondary to mastoid congestion following la grippe, one exposure 5 minutes in duration. The painful area in the case of spinal hemorrhage was relieved at once. The case of cerebral congestion slept all night after the treatment for the first time in many weeks and returned to the office the following day with lessened circulatory disturbance, facial tissues normal as to circulation (had typical belladonna face and great mental confusion), quiet mien and consecutive thought. The improvement established has continued for 3 months. Subsequently several other applications of concentrated light were used, also the convective discharge from the influence machine. In the case of neuralgia, the application was made just behind the ear. An erythema developed in 20 minutes, increasing in severity for 24 to 36 hours, the sensation being that of a burn. During this reactionary stage, the suffering was increased, the sensation being that of extreme congestion and

as though every nerve trunk and branch was held in a vise. With the subsidence of this stage, improvement began and has been continuous. The severe supraorbital, ocular, and aural pains have passed and do not appear under the influence of cold, damp, and fatigue as they did, while the neck muscles, which were not only sore but stiff, are practically normal. This stiffness of the neck muscles had lasted for 6 months prior to treatment, and at this writing, 3 months later has not returned nor have the evidences of the action of light, i.e., pigmentation disappeared. Exfoliation took place in about ten days. There has been some return of the pain on exposure to cold, damp or fatigue, but at no time has the pain been so severe as before, and especially is this true of the aural pain.

The same method has been used with great improvement in a case of incontinence consequent upon a spinal hemorrhage and complete paraplegia. In 11 weeks' time there has been a daily increase of control and from almost daily and many times a day incontinence she has been free from any trouble about two-thirds of the time. At this writing she continues to improve.

Other than the action of the chemical light frequencies on the blood there must be an immediate action upon the peripheral nerve endings, judging from the prompt and speedy relief from pain.

The biological action of light is one which yet requires much study and investigation that it may be known how it acts. The fact of the absolute dependence of the human species for existence upon solar energy is not only because of the dependence of the former upon the vegetable kingdom, but it presupposes as well a definite relation between its action and the functions of the human organism.

The Use of Light in Diabetes.—Both the incandescent and arc light have been employed to advantage in the treatment of diabetes, but because of the greater chemical activity of the arc, it is the better form of light to use.

Recently Strebel[1] has reported the results obtained by him in the treatment of a series of cases of diabetes by means of the electric arc. As per the method of Monbinow, he utilized a 25-ampère arc at 60 volts; reflecting the luminous rays upon a parabolic mirror from which they were directed upon the hepatic area. Under the influence of the light activities, the skin reddens rapidly, becoming the seat of local sweating, which may become general, if the source of light is brought nearer and if the general direction of the beam of light is reflected perpendicularly to the cutaneous surface. A rapid diminution of sugar was noted after several days' application, and finally its complete disappearance. While the results obtained by Strebel are most encouraging, they are not yet numerous enough to judge of the comparative value of the method.

The energy of the electric arc is better adapted to the needs of diabetic patients than that of incandescent lamps. It is the chemical rather than the sudative action which is desired primarily.

In chlorotic women there seems to be a congenital weakness of the blood-forming and blood-propelling apparatus, the cause of which is to be sought for in some faulty condition of the meso-blast. In them, the heart and the blood vessels are small and the absolute number of corpuscles may be diminished one-half, although the relative number may be retained, while in the corpuscles themselves the hæmoglobin is diminished almost one-third. This quantity of hæmoglobin rises after the administration of iron and other remedies and also is improved to a degree by an expenditure of various forms of electrical energy. But in the well-marked and more obstinate cases of this sort, as well as in secondary anæmias, the author has found an exposure of the entire nude body to the radiant energies of an electric arc bath of greater avail than the exhibition of drugs singly or in combination, an expenditure of electrical energy or that from water in the

[1]Light in Diabetes: Review Internationale d'électrothérapie et radiothérapie, January, 1904.

recognized hydriatic administrations. The waxen pallor, the breathlessness, the inadequate heart, the palpitations, the puffiness or œdema of tissues, the lack of strength and inability to go up and down stairs have either disappeared or become modified under the influence of an electric arc bath, with great rapidity. There has been an increase of hæmoglobin under the influence of the light, by reason of the stimulation imparted to the swing of the oxygen atoms. For as each condition of matter when its corpuscles are vibrating at their own characteristic rates causes different sets of waves varying in lengths, amplitudes and periods of oscillation[1] in the physical world, so in the human organism must the characteristic vibrations of atoms or molecules cause different sets of waves, varying in length, amplitudes and periods of oscillation and the propagation of these ultimately influences the entire blood stratum, resulting in its enrichment with normal constituents.

In all the conditions enumerated showing a departure from the normal characteristics of the red blood corpuscle, the author has found the therapeutic use of light of very great avail, with the exception of pernicious anæmia. The opportunity for treating such a case has never appeared, and even if it did, there is very great doubt as to whether any good result would ensue. Still, should the opportunity present itself, the effort would be made, for unquestionably it is the red blood corpuscle which must be acted upon in an attempt to secure a favorable result. Drugs do not avail. In the stimulus imparted by the absorption of the chemical frequencies, it is possible that the abnormally sized, irregularly shaped, and improperly distributed red blood corpuscles might assume normal shape, volume, coloring, consistence and distribution. This, however, is conjecture, and is not supported by clinical experience.

It has been stated that the action of iron administered internally is much more energetic when the nude body is

[1]Larkin: Radiant Energy, p. 51.

exposed to the action of light. The author has made no experiments in this direction, but it seems well worth investigating. The many different rates at which the oscillating corpuscles of iron vibrate, taken in connection with the physical and physiologic action of light waves upon the human organism, afford ground enough for advancing the hypothesis. Iron has a great affinity for oxygen, so also have ultra-violet frequencies. Is there a sympathetic resonance or synchronous vibration produced between the presence of the one within and the other without?

The rational hypothesis of the action of light stimulus in syphilis, not only upon the superficial lesions, but the systemic condition, is based upon its pathology of sub-oxidation.

The function of all organs so far as the effect is concerned is carried on by the plasma, the plasma depends upon the hæmoglobin for its reserve energy or oxygen, and the red-blood corpuscle is able to store a large reserve in the hæmoglobin compound.

Under physiological conditions, the plasma of the blood is the circulating fluid within the axis cylinders, and the surrounding semi-fluid media or the myelin around the axis cylinders, the white matter of the cerebro-spinal system. The reaction of nerve structures to methylene blue is due to oxygen saturation and alkalinity of the blood. In tabes dorsalis it may be possible that the normal oxygen saturation of the nerve structures is not maintained. The indication, therefore, in therapeutics is for a measure which will increase the oxygenating power of the blood in order that the red blood corpuscles may store up oxygen. At the same time the production of a more or less lasting hyperæmia of the degenerating cord is indicated.

The influence thus exerted can after all only be limited, and depends upon the extent to which the degenerative process has extended.

Clinical evidence points to a more than palliative influence in this condition. Just so far as the oxygenating

power of the blood stream can be maintained, and a hyperæmia of the intimate circulation of the cord secured just so far it is possible to combat the progress of these degenerative changes. By the action of light energy there is established a dilatation of the cutaneous vessels which determines a more active blood supply to the part. This, in turn, must be assumed to favorably influence nutrition, enabling the skin, and even deeper tissues for that matter, to perform their functions.

Locomotor Ataxia.—There is a considerable clinical evidence pointing to an actual improvement in this condition, and to an arrest of the degenerative process by the action of light energy.

The physician whose case is detailed below is known to the author personally. The history was one of extreme suffering and disability. It is very probable that the injury was the predisposing cause with the specific infection the exciting cause. In addition to his tabes he was a typical neurasthenic. Suffice it to say that up to the time of his using the electric arc light he was in a most pitiable condition. At this writing he is in a fair degree of health, does not suffer from pain, functions are well performed, and after he once has started to walk the ataxic gait is but little apparent.

C. C. G., physician, age 46, tabes. When riding on April 18, 1892, while making professional calls, his horse became frightened, overturning the buggy, and breaking both bones of the left leg below the knee, at the same time severely wrenching the lumbar articulations. The recovery from the fractures of the leg was prompt and uneventful, but the disturbance in the back persisted. During convalescence he suffered constant throbbing pain at the site of the injury in the lumbar region, pronounced pains occurring alternately at different points for the entire length of the spine, indicated the establishment of a diseased process throughout the cord. The pain was always aggravated by physical activity, and also by mental worry and annoyance. At this time a great demand was made upon him in

the care and attention he gave his invalid wife, who died June 20, 1895. The extra care, anxiety and grief increased his physical disability. After her death he suffered from insomnia, and finally developed the unmistakable symptoms of locomotor ataxia. In the late summer or fall of 1895, preceding the loss of the patella reflexes, there was induced a diminished or lost sensation of the nerves of the third toe of the left foot. Beginning at this time he experienced severe lancinating sensations in his extremities with "girdle sensations" about the chest. There also appeared the usual sensory disturbances of heat and cold, while the pains in the back grew more severe and were continuous. The usual disturbance of the intestinal function was also experienced, which was followed by ulceration of the sphincter ani. This was in turn followed by stubborn, uncontrollable, diarrhœa, with from one to 20 movements daily. The patient suffered from urethritis, cystitis, prostatitis and incontinence of urine in an aggravated form.

In the spring and summer of 1896 the pains became general, being no longer limited to the lumbar region and lower extremities. They would be severely felt in one location for an hour, or possibly for a day or so at a time, and then change to other parts of the body.

The pain in the back continued from the date of his first injury, April 18, 1892, till about the first day of May, 1893. A specific history in this case is very doubtful, the only lesion which can be associated with the possibility of such a condition occurred in the summer of 1894. An ulcer formed over the phalanx of the left thumb. It was characterized with a thick, heavy, indurated base, and resisted the ordinary methods of treatment, requiring from 6 to 8 months to heal. There was never any other evidence of specific trouble, and no secondary symptoms or tertiary lesions ever appeared. This sore was the only evidence of syphilitic infection.

The treatment administered for the locomotor ataxia was begun in the summer of 1896, and was as follows: iodide of

potash was administered in quantities as large as 600 grains daily. Following the use of the iodide strychnia was given in doses as large as 1/20 grain, 3 times daily. All these measures accomplished nothing. The patient grew continually worse until 1898, when he became almost helpless. From this time no drugs were taken, as the patient felt that medicinal treatment aggravated his condition. After carefully trying sanitarium treatment, where various plans and methods of treatment were adopted, he became discouraged. He then began the use of suggestion in the spring of 1900, but during this time the syndrome remained unchanged, pain and other ataxic conditions persisting regardless of treatment. He, however, improved remarkably in his locomotion by the methodical use of a system of exercise (Fraenkel) to re-educate his muscles. Under this he gained some flesh and strength. There was not, however, any improvement whatever in the progressive symptoms of the trouble, the cord lesion.

About March 20, 1903, treatment was instituted by means of an electric arc light bath. These baths were given in a cabinet about $5\frac{1}{2}$ feet long, $4\frac{1}{2}$ feet high, and 3 feet broad, with an arc light suspended on either end; the space between the 2 lamps being from 3 to $3\frac{1}{2}$ feet. With these lamps there was used a special carbon of German manufacture,[1] known commercially as the plain-blue carbon. Exposures were made daily for from 30 to 40 minutes, during a period of 4 weeks. At this time he had lost a few pounds in weight. The exposures were administered on alternate days for 2 weeks, and then every third or fourth day for about one month. During this period the improvement was remarkable. Following the first few exposures there was marked relief from the severe, lancinating pains from which he had up to this time suffered. Relief from the girdle sensations, gastric crises and digestive disturbances was experienced from the first, and there was also marked improvement in

[1]Mfg. by C. Conradi, Germany.

the incontinence of the urine from the first. The relief established has continued. At the end of 6 weeks' treatment he was enabled to rest almost an entire night without vesical disturbance. The diarrhœa also improved, and there was also a marked improvement from the first in locomotion and co-ordination. Reflexes are still abolished. Since the close of this course of treatment the attendance has been less regular. The patient averages 2 treatments per week at the present time. His improvement in every way is remarkable, almost, if not quite unprecedented. The doctor[1] has treated several cases since his own recovery with similar results.

Alternating-Current Electric Arc Baths.—For ar arc light bath where uniform and extensive diffusion of the light is desired to act upon every part of the superficies of the body, the alternating current is of especial value by reason of the fact that the distribution of light has two planes of maxima of intensity, one above and one below the horizontal plane. This is very clearly shown in Fig. 10,

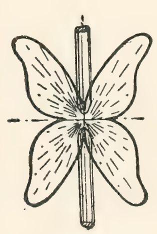

Fig. 11.

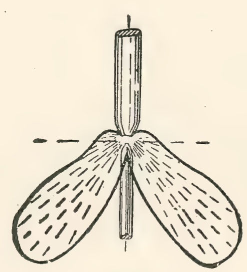

Fig. 12.

where the luminous intensity is seen to reach a maximum about 50° both above and below the horizontal plane.

The contrary is true of the luminous intensity of a continuous-current arc, as is shown in the second illustration.

[1]For the detailed history of the case, the author is indebted to the patient himself.

Very little of the luminous intensity of a continuous current arc is produced in the regions above the horizontal plane passing through the arc. The intensity rapidly diminishes as we descend below this horizontal plane, until at an angle 75° below very little light is emitted. It will be recalled that in the arrangement of the continuous arc light mechanisms in the author's cabinet the greatest intensity of light falls upon the body of the patient as they recline upon the couch within the cabinet.

From Fig. 10, it can readily be seen that from the use of alternating-current arc light mechanisms, when the patient is in a sitting position, the entire superficies of the body will be brought under the influence of a very evenly distributed light energy; but with continuous-current arcs, a recumbent or semi-recumbent position exposes the body to the greatest intensity of the light energy.

In this direction of the luminous intensity is to be found the reason for placing tubes with focal lenses, as in the Finsen apparatus, in an obliquely perpendicular position in relation to the source of light, and also the reason for allowing the light energy to fall perpendicularly upon the parts to be treated.

More recently Dr. Albert E. Sterne[1] has reported the use of a somewhat complicated cabinet containing alternating-current arc light mechanisms. In it he has placed a device for the generation of ozone and a Tesla coil for the purpose of utilizing the high frequency discharge at the same time. The individual operator can arrange a similar device if he so desires.

Since the value of light alone as a therapeutic measure in a given class of cases was established by the author it has always been customary to follow a light bath by an administration of the convective discharge from a static machine or a high frequency current. This was not done in the beginning of the use of light, but after a sufficient clinical data

[1]Journal of the American Medical Association, Feb. 20, 1904.

had been amassed to determine the action of light energy alone.

The more simple and uncomplicated apparatus lends itself to the needs of the average practitioner and an electric arc bath may be arranged by the individual physician which need neither be elaborate nor expensive in construction.

CHAPTER X.

Incandescent Light Baths. Arrangement of Light Mechanisms, Methods of Use, Therapeutic Indications. Obesity, Gout and Rheumatism, Diabetes, Anæmia and Chlorosis, Toxæmias, Nephritis.

Incandescent Light Baths.

Incandescent Light for Therapeutic Purposes.—The selection of a source of light energy and its arrangement depend entirely upon the purpose to be attained. In practical work the indications for the energy from these different sources is not always absolutely clear and well defined. They touch at many points just as in an expenditure of electrical energy or for that matter of chemical energy as with drugs. But from a knowledge of the physical properties of incandescent light, i.e., its spectrum and from its physical effects and physiological action, the conditions in which it is useful can be very clearly established.

Principles of Construction of Incandescent Electric Lamps.—The principle utilized in the construction of an incandescent light is familiar to all, viz., that when a strong current of electricity is passed through a wire of small conductivity, i.e., high resistance, its temperature is raised to incandescence. If the strength of the current is increased, the brightness of the light increases, but in a greater ratio than the strength of the current. At such high temperatures, wires, even of the metals fused with the greatest difficulty, fuse readily or are disintegrated. The only substance which does not fuse at the highest temperature is carbon. The first lamps in which carbon was used were constructed independently by Edison and Swan in this country. To Edison, however, the credit is due for finding a material from which high-grade carbon filaments are made. This is a

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special kind of bamboo, carbonized at high temperature in closed nickel moulds. By enclosing an electric light in an opaque calorimeter, the entire radiation is absorbed, then if afterward it be surrounded by a transparent calorimeter, permitting the light to pass, it will be found that the luminous radiation is about 10 per cent. of the total in the case of the electric arc and but 5 per cent. in an incandescent. The relation between the lighting power and the strength of current varies in different lamps according to the strengths of the current.

Ampèrage and Candle-Power.—A 16 candle-power Edison lamp requires a current of 0.6 ampère. As its resistance when hot is 170 ohms the potential difference at the connection according to Ohm's law would be the current multiplied by the resistance or $0.6 \times 170 = 102$ volts.

Life of Incandescent Lamps.—Under normal conditions the life of an incandescent lamp is from 1000 to 2000 hours, but it depends chiefly on the strength of the current passed through it. The life of a lamp is shortened if the current is very strong but the illuminating power varies in greater ratio than the current. Bulbs which have been used over long not only lose their normal illuminating power but require a greater amount of current to produce that power. Therefore they should be changed in incandescent light cabinets the minimum length of time rather than the maximum.

Efficiency of Incandescent Electric Lamps.—The efficiency of an electric lamp is generally given in the number of watts required to produce one candle-power. An incandescent lamp may absorb from 3.5 to 4 watts per candle, an arc light is much more efficient, as it gives one candle at the expense of less than one watt. The incandescent lamp bulbs on the market to-day are many of them inferior to those used several years since. They are more cheaply constructed, of shorter life and less efficiency. They therefore require to be changed frequently, for in an incandescent cabinet containing 50, 75 or 100 incandescent lamp bulbs, the amount of current consumed in a busy office hour is considerable.

Incandescent Light Bath—Largely a Thermal Bath.—The incandescent electric light bath is very largely a thermal bath, as the luminous efficiency is but 5 per cent. of the total output, but a cabinet equipped with 50 or 100 of such lamps gives, after all, a very large luminous output. In this per cent. of luminous frequencies all are to be found from the violet down to the red, and as they all possess greater or less chemical power, there is after all a very large chemical efficiency to an incandescent light bath. The chemical activity of the long, slow and less highly refrangible frequencies is sufficient to counteract any depressing effect of the thermal frequencies.

Spectra of Incandescent Light Similar to Spectra of Petroleum and Gas.—The incandescent light has a very similar spectrum to that of petroleum and gaslight. It is poor in violet and blue frequencies, and rich in yellow, red and green. Of the three, sun baths, electric-arc baths and incandescent light baths, the latter occupies the third place in so far as chemical light energy is concerned. Sunlight is richer chemically than the incandescent in the blue-violet frequencies, while the electric arc is much more intensely chemical as it is used, than even sunlight, because of the ultra-violet energy which it emits, and which can be used so near the light source.

Chemical Efficiency of Incandescent Light Spectra Increased by Increasing the Current.—The chemical efficacy of incandescent light as evidenced photographically is, therefore, very slight, but this, as well as its luminous output, may be materially increased by increasing the current.

This is shown by Abney's table.

Number of Grove Elements.	Illuminating Power in Normal Candles.	Photographic Effect.
12	0.132	immensurable
14	0.26	0.35
16	1.17	1.61
18	2.44	5.83
20	3.84	12.84
22	6.85	36.45
24	10.38	86.60

It is not only the luminous output or optical brightness that is affected by increasing the strength of the current, but also the quantity of blue and violet frequencies.

Chemical Equivalent of Incandescent Light.—It is estimated that, as a rule, 380 incandescent lamps of normal power without reflectors have the same chemical effect as natural light, at a distance of one metre from the object.

The Nernst Lamps for Incandescent Light Baths.—In the Nernst lamp there is to be had a light richer in chemical frequencies than the ordinary incandescent lamp. By their use a light twice as intense is obtained of a pure white or rather greenish color, and, therefore, more from the chemical end of the spectrum. Of all the electric energy consumed in an incandescent light bath, but 5 per cent. is accounted for in the luminous activities. This does not include the red, blue and violet frequencies, which bring it up to 30 per cent. With the Nernst ½-ampère lamp, this percentage is raised even to 60 per cent.

The Radiant Efficiency of the Nernst Lamp.—The efficiency of new Nernst glowers was found by Ingersoll,[1] who carefully tested them to vary from 4.35 per cent. to 4.70 per cent., with a mean of 4.61 per cent. The efficiency falls rapidly for the first 20 hours, decreasing to 4.3 per cent., but varies only very slowly after this. In making these experiments Ingersoll maintained the power constant, not the current, as was done by Hartman, which accounted for his different figures as to decrease in the efficiency. Some very old lamps tested gave efficiencies of only 3.6 per cent. The lamps were all 110-volt glowers, consuming 89 watts, and for every watt above 89, within narrow limits, the efficiency increases 0.06 per cent., and below this, vice versa. The energy curve (Wiens law) gives the efficiency as 4.17 per cent. These tests were made in such a manner as to cut off all the invisible frequencies, giving only the radiant

[1]The Physical Review, Nov., 1903.

efficiency of the lamp. In common with the incandescent old lamps lose their efficiency, and in baths constructed either with the one or the other, the lamps should be renewed frequently. This not only means greater efficiency but less consumption of current.

The Nernst lamp, by reason of the fact that it does not require a glass covering, although provided with one, offers a means of supplying the frequencies needed in therapeutic work, although not to the same extent as the arc, still greater than the incandescent lamp. In this lamp the source of the light is a rod of zirconia acted upon by the electric current. As there is no glass enclosing bulb, there is no loss of the short and high frequencies, as in the incandescent. For a therapeutic cabinet it is useful and fewer of them would be required, owing to their greater efficiency. Still another advantage over incandescent bulbs, is that for the same consumption of current the number of light waves is greater, as less of the current is converted into the longer heat waves.

First Introduction of Incandescent and Radiant Heat Baths.—Incandescent light baths were first introduced by Kellogg and the radiant heat baths by Hedley. In 1894 Kellogg presented a paper to the American Electro-Therapeutic Association, giving a very exhaustive résumé of his work with incandescent light baths. About the same time Hedley, of London, called the attention of the Balneological Society to an apparatus which he had devised for the purpose of applying to the body direct heat rays from a luminous source.

Winternitz has particularly interested himself in the development of this therapeutic measure.

Hedley's device consisted of incandescent lamps, each carrying 2½ ampères of current, fixed in reflectors. This apparatus has been in use ever since. The well-known Dowsing radiant heat baths are constructed upon this principle. The devices of both Hedley and Kellogg have fully stood the test of time. The fundamental principle in the construction of baths for this purpose is the same in every

instance. These cabinets were subsequently introduced into Germany by the chemist Gebhard, where they are very extensively used.

Incandescent Light Mechanisms.—Incandescent light mechanisms may be arranged for either general or local work. In the former instance, cabinets are constructed on the principle of the Kellogg cabinet, and the energy of varying numbers of incandescent lamps from 50 to 100 or more utilized therein. Kellogg's first use of incandescent light energy was with single lamps where the energy was localized and concentrated. This method is considered in detail in Chapter XIII. The results obtained from their use in this way were so excellent that he was led not only to the grouping of a few lamp mechanisms for the purpose of concentrating the light energy upon a part, but to the construction of an apparatus for the exposure of the entire nude body.

First Incandescent Light Cabinet.—His first cabinet consisted of a frame about 2 feet in width, which supported a metal reflector and from 20 to 30 incandescent lamps. The frame was attached by hinges to a support in such a way that it could be raised or lowered at will. The patient was exposed in a recumbent position upon a couch placed beneath it during the time of treatment. When the one surface of the body had been exposed for a sufficient length of time, the patient turned over exposing the other side of the body to the light energy. Later on he had cabinets constructed at first a vertical and then a horizontal one. These cabinets are constructed at this time of different forms and sizes according to the needs of the individual practitioner.

Incandescent baths may be arranged either for a sitting or a recumbent position of the patient. The principle is the same in each instance. As a rule, they are arranged for the sitting position, although one of the Kellogg cabinets is arranged for the recumbent position.

Horizontal Incandescent Light Bath.—In this the patient reclines upon a glass-covered couch, while from above

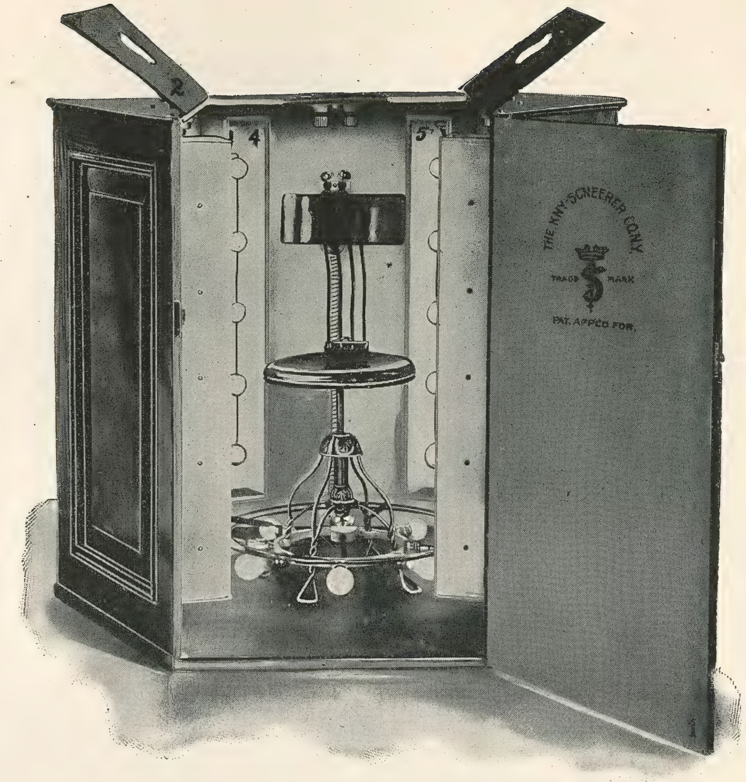

Fig. 13.—Incandescent Cabinet Open.

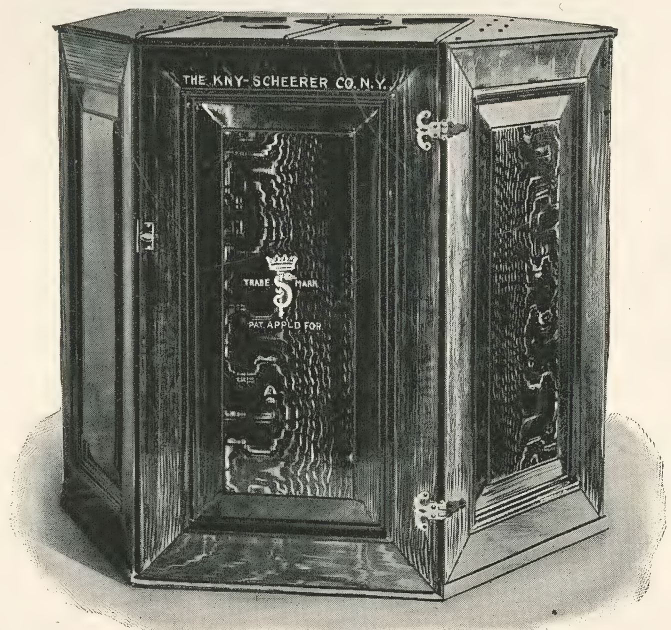

Fig. 14.—Incandescent Cabinet Closed.

him and below him, and also on every side of him, the energy of about 100 16-candle-power incandescent lamps, reflected and multiplied by polished mirrors, is directed to the body superficies. The couch is movable, mounted on wheels, that it may easily be run in and out. The glass covering of the couch permits the action of the light energy upon every square inch of the exposed body. Here there are no limiting ultra-violet frequencies to prevent the use of the glass. The head remains outside of the enclosing cabinet during treatment while a curtain shields the patient's eyes from the action of the light.

The vertical cabinet described by Kellogg, required to energize it from 20 to 40 16-candle-power lamps. Different operators vary the number according to the conditions to be met.

These incandescent light cabinets generally, however, consist of octagonal boxes arranged for connection with the street electric wires. They may be operated either by a continuous or an alternating E. M. F., and the one is as good as the other for the purpose. They are variously supplied with mirrors, opalescent and colored glass plates, to be used at will. A door permits the ingress and egress of the patient, who in the enclosing cabinet sits upon a stool. There is also a movable divided lid fitted on the top with a hole the size of the patient's neck, and from which the patient's head emerges. The cabinet shown in the illustration is one of the most complete cabinets constructed by the manufacturers for the purpose of an incandescent light bath. As will be seen it is a cabinet in which the patient sits with the head out while exposed to the action of the light energy. The framework is constructed exclusively of steel. This completely obviates any danger from fire in the event of a defective bit of insulation. It is provided with 38 lamps, and consists of 6 drawn sheet steel panels, steel top with head and hand holes, steel bottom, metal chair, with door at front and 2 doors in the top, as shown in cut (Figs. 1, 2 and 3).

Thirty spherical incandescent lamps are arranged in 6 channels (Figs. 4 and 5), said channels being provided with violet or ruby glass screens, which are hinged to one side of the said channel, and so arranged that they may instantly be changed or opened to give access to the lamps within. Eight lamps are also arranged around the bottom of the chair. Each set of lamps is on an independent circuit, and each may be controlled separately by means of switches conveniently arranged on the underside of the top of the cabinet. In this manner the temperature within the cabinet may be closely regulated.

All wiring is of the latest approved style, enclosed in steel tubes, and such as approved by the New York Board of Fire Underwriters. The wiring is so arranged that the cabinet may be operated on 52 or 104-volt alternating current, or 110 or 220-volt direct current. To this end it is merely necessary to insert lamps of the equivalent voltage.

The simplicity of the construction of this cabinet is such that it can be set up in a few moments by any one following the directions.

The channels carrying the lamps are supported on hooks at their back, and the lamps therein connect to junction boxes on the underside of the top of the cabinet by means of plug switches. The panels are held in place by small clamps, which also serve as a support for said lamp channels.

To facilitate shipment and simplify the installation of the cabinet by a novice, it is so constructed that it may be entirely taken apart without interfering with any of the electrical connections or other parts.

This is accomplished by removing the plug switches at the top of the channels, lifting the top off, raising the channels from their hook supports, removing the screws in the clamps holding panels together, and withdrawing the two hinge pins. In setting it up the reverse of the above direction must be followed.

Dr. Italo Tonta[1] made several improvements in his incandescent light bath, which are worthy of attention. First he provided the top of the octagonal-shaped cabinet with a cupola-like cover, with angles so disposed that it is possible to concentrate the light energy upon the body of the patient. In one of the posterior faces of the cupola he has provided a ventilating device operated by a small electric motor, the speed of which is controlled by suitable resistance, as he regards the want of ventilation in an ordinary cabinet a great fault. In the thickness of the 2 lateral doors below are 2 openings the size of the palm of the hand closed by small metallic plates which are provided with mirror surface upon the inside. Those are for the entrance of dry air, which can be introduced into the cabinet when the ventilator is in action. When these are closed and communication established between the ventilator and the external air the hot air inside the cabinet is agitated. Seven circuits of a series of 8 lamps each are provided. These are placed horizontally. The last circuit comprises 2 lamps placed under the bench designed for the feet. Screens of different colors are provided to eliminate at will different frequencies of the spectrum. The roof of the apparatus is provided with a groove in which the cover, divided into two parts, glides. This is so arranged as to fit exactly about the neck of the patient. In this cabinet the refraction of the light is horizontal and diagonal. The walls of the cabinet are of wood, covered upon the inside with mirrors. In the fixed part of the cover a thermometer is placed in a neutral zone, i.e., a part that is not exposed to the direct radiation of the light. There are provided openings in the walls of the cabinet for the purpose of observing the cardiac movements, and at the same time of the condition of the skin as to transpiration and by an introduction of a hygrometer to estimate the humidity of the air. These can be opened or shut at will. An adjustable chair within the

[1]The Light Bath Congress of Electrology at Berlin, Revue Internationale d'Électrothérapie, Nov. and Dec., 1902.

cabinet permits the patient to be placed at the desired height. This detailed description is given because the apparatus has many good points. The individual operator can have all these details of construction embodied in his incandescent light cabinet if he wishes.

The method of ventilation the author regards as extremely advantageous.

Combined Incandescent and Arc Light Cabinets.—Sometimes these cabinets are constructed in such a manner as to contain both incandescent and arc lamps to be used simultaneously or separately, as the operator desires. While combination incandescent and electrical arc baths are not recommended they can be used where floor space prohibits the placing of two equipments. They should be so constructed that either the light energy of the incandescent or that of the arc can be used separately or conjointly, as desired. The action of the incandescent bath, as compared with that of the electric arc, is to be regarded as that of thermal energy, while with the electric arc bath the action is primarily a chemical one.

The author prefers to project the light from an arc light mechanism provided with suitable reflecting mirror, as the marine searchlight, upon the patient seated within or without the cabinet, according to the environment rather than to have electric arcs permanently placed in an incandescent cabinet.

Effects of Incandescent Light Baths and Electric Arc Baths not to be Confounded.—The effects of these should not be confounded with the effects of electric-arc baths. The latter whether used in such a way as to secure the influence of all the activities of the arc, or the exclusion of the thermal frequencies, is in the highest sense a chemical light bath because of the exceeding richness of the electric arc in the chemical frequencies. The latter is richer in the ultra-violet than the sunlight as we use it, while the former is not even comparable chemically with sunlight. But even so, the incandescent baths occupy a very important place

in therapeutics. They are useful by means of their radiant heat, in addition they have a chemical power by reason of the blue, indigo and violet frequencies, for which the glass is transparent. As a source of light the incandescent lamp is not rich in these frequencies, but as the glass does not preclude the passage of those emitted, and as many of them are used in a given light bath equipment, from 25 to 100 or more, it follows that after all an incandescent light bath has a very decided chemical power. It is more than a sudatory or transpiration bath, and even so, as such, the heat produced is of a different quality from that which proceeds from hot air or steam. A number of these gathered together in a small area, as in a therapeutic cabinet offer very great chemical power. Even a candle as a source of light has sufficient chemical power to render it necessary to use a dark red glass in the examination of a sensitized photographic plate.

Advantages of Incandescent Sudatory Baths over Hot-Air or Vapor Baths.—The advantage of these baths as sudatory or transpiration baths is to be found in the fact that heat reaches the interior of the body by conduction, after penetrating slowly through the layers of the tissues that oppose by their inherent construction, a great resistance to the passage of heat rays, but allow light waves to pass readily. With an incandescent light bath, even though applied as a sudatory bath, in conditions where profound elimination through the skin is desired, in Bright's disease, for example, the time of application is much shorter than with the hot air or the vapor bath. This is due to the fact that in addition to the thermal activities there is an influence also of the longer and slower frequencies; the red, yellow and green, as well as from the more refrangible blue-violet up to the ultra-violet. There is a very small per cent. of blue-violet emitted by a single incandescent unit of light, however. The red and low frequency waves are transformed into heat, while the higher visible chemical frequencies exercise (1) their characteristic action upon the skin and superficial circulation and (2) upon metabolism.

An incandescent light bath, then, is active by reason of its thermal, luminous and visible chemical frequencies. The latter are much less than in the sun or electric arc, therefore where the maximum chemical effect is desired in a general bath, either the sun or the arc should be selected.

Penetration, Absorption and Transmission of the Varying Frequencies of Light Energy by the Living Tissues.—Kellogg found "upon examining by means of the splanchnoscope a human body on whose abdomen a single incandescent lamp of 16 to 32 candle-power was burning, the whole true pelvis shown with a bright red light." As noted on a subsequent page, a miniature incandescent lamp within the vagina will cause the pelvic tissues to within 2 inches of the umbilicus to glow with red light. The area of the stomach is beautifully outlined by the translucency of the tissues to the light of the miniature lamp placed therein for diagnostic purposes. It is only necessary to hold a hand before the source of light or sunlight, for that matter, to be assured of the penetrability of the other rays of light, even through the bones and to the innermost parts of the body. The blood absorbs the chemical frequencies of light, blue, violet and under pressure the ultra-violet as well, according to the law of color absorption. The fact of the fluorescence of the blood indicates a penetration of the frequencies or energy of radiation which the oxygen molecule is capable of absorbing according to the law governing absorption of light. The action upon the peripheral blood supply does not end at the periphery, but must, by its very nature, go on and to the innermost depths, the degree and constancy of effect depending upon the character, length and frequency of exposures to light energies. It seems to the author that there can be no question but that the red rays which penetrate so deeply and which exist in such abundance in an incandescent bath are of value. Just what their function may be is perhaps not so clear as with the chemical frequencies, but function in the very course of nature they must have.

It must not be understood that red frequencies are synonomous with thermal frequencies. The thermal activities must be regarded as invisible heat in contradistinction to such visible heat as characterizes the red frequencies.

The Influence of Incandescent Light Energy upon the Skin.—There is produced by the action of these baths an intense reddening, i.e., hyperæmia of the skin. This indicates a dilatation of the superficial blood vessels. This is a simple hyperæmia, unlike that produced by the chemically active energy of solar light and the electric arc; and unless there has been an intense heat effect, scorching of the skin, it disappears very quickly, as do all hyperæmias brought about by radiant heat, leaving no traces of erythema or of pigmentation. The scorching effect alluded to should never be permitted. Kellogg found from frequent repetition of these baths that the skin did become pigmented or brownish in color, as from exposure to the sun's rays. It is quite possible that frequent repetition, prolonged application and great light intensity may produce pigmentation, for under those conditions there is after all a considerable chemical light intensity operative.

The Influence of Incandescent Light Energy upon Sudation.—This is one of the most marked phenomena from this mode of treatment, and to the profound action upon the sweat glands much of the good derived from its use must be attributed. It is produced more quickly than by any other known procedure and generally appears within from 3 to 5 minutes after entering the bath and quite regardless of the temperature of the bath. Winternitz observed it at 86°F., 30°C. Much longer time is required in the hot air or Turkish bath. This action is unquestionably due to (1) a stimulation of the peripheral nerve endings and (2) to raising the temperature of the patient's body by the action of the radiant heat. As a chemical light bath (the electric arc, where the temperature of the cabinet is but little elevated) stimulates the activity of the sweat glands, the inference is drawn that the action is due in part to a stimulation of the peripheral

nerve endings which follows upon the action of the chemically active energy of an incandescent light bath. Vigorous perspiration may be induced in a small area of the body by the action of the incandescent light energy, indicating that the effect is due rather to the radiant energy of these light sources, than to the hot air of the enclosing cabinet. The parts exposed most directly to the light are first affected.

It was observed by Kellogg that the amount of sweat excreted in the incandescent bath was twice as much for the same time as in the Turkish bath, while the average temperature in the former was 81°F. and in the latter was 140° to 148°F. He also noted that with 50 lamps in operation, the perspiration began in 6 to 10 minutes at a temperature of 95°F. If the temperature of the cabinet is raised to 140° to 158 F°. sweat to the amount of a litre may be excreted in a quarter to a half an hour.

Kattenbracker found 0.26 per cent. of sulphur in the sweat of a glass blower, while the very interesting fact is noted by Below and Aufrecht that traces of mercury were found in the perspiration of persons who had been treated by mercurial inunctions years before.[1]

Crothers[2] notes the marked action upon the secretory centres and that the elimination of fluid is rapid and intense. He finds that patients suffering from toxæmia are profoundly affected by the action of the light baths. In neurotic patients on the other hand the stimulation may not be noticed for some time. This would indicate a diminished power of response of peripheral nerve endings in the latter condition.

Under the influence of electric light a higher temperature from stove heat can be borne with impunity by plants than without it. This was proven by Siemens in his experiments upon plants.

It is the consensus of opinion that the temperature of

[1]Quoted by Freund.
[2]New York and Phila. Medical Journal, July 23, 1904. The Radiant Heat Baths.

an incandescent bath and its accompanying effect upon the sweat glands is better borne than a hot air bath. It is much more life-giving, less depressing in its action, an effect which can only be accounted for by the presence of the higher and shorter frequencies. It is not necessary in an incandescent bath to have as high a temperature for the production of transpiration as in hot air or vapor bath because of the action of the other frequencies upon the skin. This action is produced by all the frequencies, including the red, as they all possess more or less chemical power. Therefore, transpirations occur at comparatively low external temperature.

The Influence of Incandescent Light Energy upon the Heart, Pulse and Tonicity of the Arteries and Blood-Count. The statement is constantly made that incandescent light baths do not influence the heart's action. Experimental observation contradicts this statement. In general it may be said that it does not affect it unfavorably as does hot air and vapor baths. M. Roth[1] observed that a pulse which before the light bath had been steady at 72 beats increased rapidly after 10 minutes in the cabinet to 84 beats. After 15 minutes, it gave 104 beats and after 20 minutes 132 beats. At first it remained fairly steady and later on it grew galloping and irregular. The same effect was observed by Stasser[2] and Strebel.[3]

Kellogg found that under its influence the pulse is first quickened and then slowed. Freund observes that it must be conceded that with a temperature in the light cabinet at 122°F. the pulse is quicker each minute by about 15 to 20 beats. Crothers[4] notes that the tension of the arteries invariably fell from the action of these baths. Contrasting it with the hot air bath, he found that the tension did not always change from the action of the latter, unless the time

[1]Med. Wochenschr., 1899, No. 19.
[2]Encyclop. Jahrb. 1900.
[3]Quoted by Freund.
[4]Radiant Heat Bath, N. Y. Med. and Phila. Med. Journ., July 23, 1904.

of using it was prolonged. The changes in the pulse he found more marked in the hot air than in the radiant heat bath, usually rising while in the former and falling in the latter. In measurements of the pulse, temperature and tonicity of the arteries the radiant heat bath showed great superiority.

There is then no question of their influence upon the heart pulse and arterial tone, and while the pulse is elevated by the profound and primary action upon the peripheral circulation, still the acceleration of the heart's action is within limits of safety. This is so true that with the precautionary measures insisted upon these baths may be used safely even in grave cardiac disorders. The changes which take place in the pulse are as a rule not so marked in succeeding baths. One of the immediate results of the use of these baths is an increased blood pressure. In most cases, however, this subsides after copious perspiration from a stay of from 20 to 25 minutes in the bath. Sometimes congestion, with bleeding at the nose, has been observed as a result of this increased blood pressure. This is not general. Kellogg found the blood count of the red cells especially markedly increased, 10 to 20 per cent., by the incandescent light bath when followed by the usual cold bath. The increase appears within half an hour.

The Influence of Incandescent Light Energy upon Respiration.—Respiration is very markedly affected by the baths. Kellogg notes that it is free and unembarrassed although somewhat quickened. It becomes twice as rapid after a short stay, 15 minutes, in the light cabinet and is at the same time more shallow and superficial.

Following these baths, the respiration becomes uniformly regular and normal. Kellogg[1] noted a decided increase in the elimination of carbon dioxid, evidencing the active oxidation and tissue changes set up by their action. In his observations of 1894 he noted that the average percentage of carbon dioxid eliminated during a 30-minute incandescent

[1]Physiologic Therapeutics, Cohen.

light bath was 5.13 per cent. in a patient who previous to the bath was eliminating 3.60 per cent. an increase of 44 per cent. From a 5-minute exposure the increase was 4.10 per cent. and for a 20-minute exposure 4.20 per cent. In a Russian bath the same subject eliminated an average of 3.96 per cent., an increase of 10 per cent., while in a Turkish bath of 30 minutes' duration the average elimination was 4.11 per cent., an increase of 11 per cent.

Action upon the Urinary Secretion.—In this connection it may be noted that Roth and Kellogg both studied the action upon the urinary secretion. The latter found a diminution in the amount of urea, of the total chlorids and total solids. From Roth's investigation upon the urine and perspiration, these baths do not seem to have any especial marked influence on organic decay in the body.

The Influence of Incandescent Energy upon Body Temperature.—It was observed by Kellogg that there was quite a rapid rise in body temperature from the action of incandescent light baths. In from 10 to 15 minutes he noted an elevation of from 4° to 5° above the normal. Freund places it about 2°F. This is noted by all observers, and the increase in body temperature tends to increase the combustion of fat. The increase of temperature necessarily varies with the duration and intensity of the bath. The difference between the estimates of Kellogg and Freund can be accounted for no doubt by the method of taking the temperature. In Kellogg's observation the extreme rise was noted upon taking the external temperature, the difference in the internal temperature being after 5½-minute exposure 1.6°F. very near that given by Freund.

The Influence of Incandescent Light Energy upon Bodily Weight.—There is a marked influence of these baths upon body weight, the diminution bearing a relation to the duration and intensity of the bath and its effect upon the perspiration.

This is apt to be counteracted by too free drinking of water. As a result of the profound elimination through

the sweat glands there is usually intense thirst. In most conditions it is better to drink freely under these conditions, and sometimes during the bath. In cases of obesity it is necessary to control the amount of fluid ingested, because it defeats the object to be attained. This should only be done within physiological limits, however.

The Influence of Incandescent Light Energy upon Bacteria.—This form of light energy cannot be regarded as bactericidal, as the bactericidal rays are placed in the middle third of the ultra-violet region. The action of light energy in bacterial diseases does not depend upon an actual destruction of the micro-organism (an impossibility in living tissue no matter what the source of light energy), but upon its action in producing a hyperæmia of the part treated. There is secured by the stimulus imparted increased oxygenation of the blood, and nutritive changes are established which increase the physiologic resistance.

A favorable action of light has been noted by various observers on infected animals, and in this connection Kondratiew, DeRenzi, Kutschuk, and Aufrecht[1] may be mentioned. There is, however, no specific action on the part of the energy of incandescent light. This has been fully established by the mass of evidence as to the action of light energy upon bacteria.

It was observed by Drigalsky[2] that mice inoculated with splenic fever or other bacteria died more quickly in the incandescent light bath than control animals even though they were kept only a short time in the bath. His explanation of this untoward effect is the rational one, viz., that the resisting power of these animals was reduced by the copious perspiration induced by the thermally active energy.

In this connection he wisely calls attention to the danger to many feeble patients, such as the tuberculous, from its use. The author regards the use of the incandescent light bath as absolutely contra-indicated, and never under

[1]Quoted by Boeder.
[2]Quoted by Freund.

any circumstances uses or recommends its use in this class of cases. As shown in considering the electric arc bath, the indication in these cases is for the intense chemically active light energy of the sun and the electric arc.

As the bactericidal energy is the same which excites tissue reaction it follows that incandescent light energy, useful as it is in a very considerable range of disease, is practically of but little value in the treatment of any condition requiring intense chemical activity, as in lupus. It best meets on the other hand all conditions where, in addition to a slight chemical effect, there is desired the longer and slower frequencies of the lower end of the spectrum, active thermally. There is, therefore, no question of using it in chronic skin lesions where the short and high frequencies of the blue violet and ultra-violet are so useful. It has a field of usefulness, however, in more recent pathological skin conditions, and especially where thermal energy is indicated as well. It is also of value in minor surgical conditions, as shown in Chapter XIV.

Sensitization.—There is a possibility that by rendering the tissues sensitive by suitable media, that the energy of incandescent light can be rendered more effectual. For this purpose solar energy or that of the electric arc are to be preferred.

The Mode of Action of Incandescent Light Energy.—The physiologic effects of incandescent light baths are due (1) to radiant heat, (2) to chemical energy. This chemical energy, so far as the blue-violet is concerned, is small, ultra-violet none, but it must be remembered that the different frequencies of the spectrum are thermal, luminous or chemical in relation to the substances or structures upon which they fall. It is not known that the longer and slower frequencies below the blue have a chemical action in relation to living tissues, nor again is it known that they have no such action. It is known that they penetrate, and that there is absorption above the red. Absorption does not take place without work being done. The exact nature of that

work is conjectural. On the other hand, in an incandescent bath the blue-violet are to be reckoned with, their chemical intensity for a single unit of light is small, but for 50 to 100 such units it is considerably magnified. Therefore the physiologic effects are to be ascribed to a chemical as well as a thermal energy. The interposition of the body tissues suffices to transform this twofold energy into thermal and chemical energy. The skin is a poor conductor of heat, but transmits radiant energy readily. The heat enters the body as a radiant force, and in this way the heat is carried to the tissues. It is not confined to the surface, as is the case with conducted heat from water vapor or Russian or Turkish baths.

Moeller showed that in radiant energy baths the heat rays readily penetrate even bones. The penetrating light rays below the blue, i.e., the red, yellow and green, considered in relation to molecular activity would seem, by reason of their length frequency and amplitude of oscillation, incapable of exciting chemical action. They doubtless undergo transformation into heat in the deeper structures. This action may readily influence excessive perspiration and excessive drainage of the deeper tissues. It is in turn followed by marked sedation, which can readily be accounted for by the sudden and intense drainage through the skin of the accumulated products of the disturbed chemico-vital action of the system.

The Action of Incandescent Light Energy in Health.—The action of these baths was studied by E. Rosen[1] upon healthy men. Following a series of 12 of these radiant heat baths, a marked improvement of appetite and sleep was noted. There was also a gain in weight. These favorable changes seemed to be lasting. There was now a numerical increase, now a diminution of the cells according to Rosen.

Therapeutic Indications for an Expenditure of Incandescent Light Energy.—Incandescent light baths have been

[1]Russky Vratch, March, 1903.

found useful in conditions of (1) lowered nutrition, the acid dyscrasias, rachitis, osteomalacea, (2) in the lipogenous dyscrasias, obesity, biliary lithiasis, gravel, diabetes, arthritic manifestations of gout and rheumatism, (3) in alterations of the blood state, anæmia, chlorosis, lymphostasis and syphilis, (4) in nervous conditions, tabes, neuralgias, hysteria, psychoses, (5) in respiratory and circulatory conditions, bronchitis, bronchial asthma, cardiac hypertrophy, (6) in diseases of the kidneys, nephritis, (7) in surgical conditions, chronic tubercular ulcers, inflammatory diseases of bones, chronic leg ulcers, paralysis and trophic disorders, (8) in toxæmias, alcohol, drug and metallic poisoning; (9) as a hygienic measure. In some of these conditions they form the remedy *par excellence,* in others an exhibition of a light energy more profoundly chemical in its action is indicated, i.e., solar light or electric arc light energy. The indication for the one or the other is pointed out as far as is possible, but there only need to be kept always in mind the nature of the energy and its action, in connection with the nature of the condition, in order to choose intelligently the one or the other. Incandescent light energy may take the place of the other two to a certain degree if the individual equipment contains but the one instalment.

The Therapeutic Effects of Incandescent Light Energy.—(1) There is established by the action of these baths a profound action on the vaso-dilators of the arteries. By the stimulation imparted to them the blood is permitted to flow more rapidly to the surface. In this way the heart is relieved of its burden, and, at the same time, the constriction to the arterial circulation and the capillaries is also lessened. From this action there ensues lowered tension of the blood stream with an increase in its volume and uniformity. A marked effect upon sensory centres is noted, as is evidenced by a diminution of nerve irritation and debility.

(2) There is established a profound revulsive effect by the dilatation of the cutaneous vessels. For the time being

the blood is fixed in the skin, the "peripheral heart." In this way passive venous congestions are connected with active arterial hyperæmia.

(3) Profound action upon the sweat glands with corresponding elimination actively.

(4) Increased oxidation.

There results from these effects a return to normal skin activity, normal circulation and oxidizing power upon the part of the organism. The general tone is increased and with it physiologic resistance.

Preparation of Cabinet and Patient.—The first depends upon whether it is desired to secure the sudden effect of powerful light action. This would be indicated in robust persons and for such the cabinet should be heated beforehand. The sudden impact, as it were, of this radiant heat at high temperature imparts a greater stimulus, just as a powerful static spark does. In weaker and more fragile patients the air of the cabinet must be heated gradually after the patient is placed therein. The temperature may be gradually increased by switching in additional lamps or adding to the ampèrage by means of the controlling resistance.

The patient is placed naked in the vertical or horizontal cabinets on a stool or slab of glass. A towel may be placed about the neck to prevent the passage of the heated air or light from the enclosing cabinet. A cold bandage, ice, or coil of cool water is applied to the head.

The condition of the pulse must be carefully observed and the admission of fresh air to the patient cared for.

Duration of Treatment.—These baths should be used for varying periods of time according to the effect desired. When the object to be attained is that of sudation or transpiration, the longer exposures and the use of all the lamps within the cabinet are necessary. Where a tonic effect only is desired, however, then a very short exposure, and a fewer number of lamps, i.e., diminished energy of radiation. For the first purpose from 15 minutes to 30 or in conditions calling for profound action even longer. For a simple tonic effect from 3 to 5 minutes suffices.

Frequency of Treatment.—Here, as with other measures, the nature of the case must influence at least the frequency of the treatment. In some conditions and for a limited time, daily baths may be given. Where profound eliminative effects are desired this may be done and also for the promotion of absorption of inflammatory exudates. But, as a rule, the need for daily exposures will be met by the first 3 to 5 treatments. After that from 3 times, twice to once a week. Too frequent an expenditure of energy is as harmful as too prolonged an expenditure. The needs of each individual patient must be conserved by the skill, experience and care of each individual operator.

After Treatment.—This should assume the form of a bath, douche or wet pack.

It may be further supplemented by mechanical measures, as massage, vibration or by the use of the electric current. Each case will present its own indications, the rationale of it all being to use such a measure as will best assist in securing a return to physiologic circulatory conditions without overtaxing the patient.

Feeble patients should always rest for shorter or longer periods of time. The author believes that the best good of the patient is attained by a period of rest immediately after the expenditure of any form of energy. This applies to those who are frankly ill, not to robust patients who use this form of light energy as a hygienic measure. As a hygienic measure incandescent light baths are of value. This fact is taken into account occasionally in the fitting up of men's clubs. Such a light bath from once to twice and three times weekly for 5 to 10 minutes, followed by a bath, or a short plunge at from 65° to 75°F., or a vigorous douche at a temperature of from 50° to 60°F. will amply repay the individual. In the conservation of the physical forces and the prevention of disease there is to be found after all the physician's highest work.

Incandescent Light Energy in Obesity.—In the use of these baths in obesity there must only be considered (1) the pathological nature of the condition, and (2) the physiological action of light energy from this source, to appreciate at once its very great value in this class of cases. Obesity is fundamentally a condition of suboxidation and imperfect eliminative processes. Moreover, it is apt to be associated with grave dietetic and hygienic errors. There is not only the powerful action of incandescent light energy, when thus concentrated upon the sweat glands, but there is as well a profound and penetrating action upon the deeper structures of the skin, and of the tissues of the body as well. As a result nutritive as well as eliminative changes are established. A considerable part of the light energy thus absorbed is converted into heat, which serves to stimulate to an unusual degree the consumption of fat, as is evidenced by increased carbon dioxid elimination.

According to Kellogg, there is more than 40 per cent. increase in tissue consumption. This in view of the fact that at least three-fourths of the energy of the body is consumed in heat production becomes a matter of the highest importance.

By an expenditure of this light energy over considerable periods of time, an hour or more, there would result a considerable loss of fat.

Conrad Klar[1] has shown that the heat elimination may be increased to more than ten times the normal amount and that it may be continued not only for a few moments but over considerable periods of time, when the temperature of the air surrounding the patient is below the temperature of the body, provided that the blood vessels are maintained in a state of active dilatation, as is possible with an incandescent light bath but in no other heating procedure.

Winternitz has observed after one such bath followed by a douche, that the weight has diminished from 700 to 800

[1]Physiologic Therapeutics, Cohen.

grams. Eiffer, Gautier and Imbert de le Touche have obtained equally satisfactory results without enfeebling the patient or obliging him to submit to debilitating dietetics. The bath need not in such cases be of high temperature, 98.6°F., 37°C. Winternitz has observed the appearance of perspiration at a temperature not above 86°F. or 30°C. While care should be taken in patients where cardiac function is enfeebled, still even with them these baths are very well borne. There is usually an acceleration of the pulse but it remains full and regular.

Chasserant[1] records a case where it was a question of a mixed form of obesity, in which by an unimportant restriction in the régime, combined with incandescent light baths, there was obtained at the end of about 6 weeks a diminution in weight of 25 pounds. In another case, where it was a question of the constitutional form, the patient although always eating little had continued to increase in weight. She had tried to limit the amount of food to the strictest minimum without any result. Incandescent light energy was prescribed in the form of the cabinet bath to be followed by massage, without modifying her normal régime. At the end of 40 days, during which time she had taken 38 baths, there was a diminution of 30 pounds in weight. For 6 weeks treatment was discontinued, during which time she increased 5 pounds in weight. Further treatment for 2 weeks resulted in a loss of 10 pounds. While it is best to combine the expenditure of some other form of energy, hydriatic measures, electricity, massage or physical exercise with the expenditure of incandescent light energy in these cases, still there is no question but that in the case recorded the diminution in the weight should be attributed to the action of the incandescent light energy, for experience has taught us the futility of massage to reduce the weight in the same class of cases.

[1]Treatment of Obesity by Baths of Electric Light. Rev. de Therapeut. March, 1902. Rev. Internationale d'Électrothérapie et Radiothérapie.

The diminution of weight in these cases is more or less according to the amount of perspiration. This is usually accompanied by extreme thirst (not alone in obesity, but in all classes of cases where prolonged exposure to intense incandescent light energy is employed), which if satisfied may counteract to a certain extent the good effect. The dietetic régime should therefore receive attention.

According to Strasser[1] this form of light energy is especially suited to the hydræmic forms of obesity, particularly the anæmic, pasty-looking type found in young people. For the plethoric type of corpulent patients he prefers packs.

The temperature of these baths may vary from the minimum to a maximum, which differs with different operators. Kellogg[2] has placed it at from 150°F. to the highest temperature tolerable. It is reported that some French observers have employed a thermometer the bulb of which is covered with lampblack, a great absorber of heat, which is also fully exposed to the action of the thermally active energy by being placed upon the patient's body. Therefore their measurements are not to be relied upon.

According to Strebel, the temperature should never exceed 113°F. for this class of cases. The author regards this a safer temperature, but each case must after all govern itself. There are some obese patients who will withstand a very considerable expenditure of light and other forms of energy; while on the other hand there are those whose endurance in this regard is limited.

The Influence of Incandescent Light Energy upon Gout and Rheumatism.—Perhaps incandescent light energy does not lend itself to the securing of better results in any other class of cases than these. There is obtained from these baths in both gout and rheumatism rapid relief from pain and other symptoms. The exposures may be either general or local or general supplemented by local where especial joints are implicated. A certain discrimination is required,

[1]Blätter f. klin. Hydrother. 1900, Nos. 4, 5, p. 94.
[2]Kellogg: System of Physiologic Therapeutics, Cohen.

however, in their use. In gouty patients it is not always well to call too severely upon the fluids of the body, as a thorough transfusion of the tissues with fluid is desirable. Under these circumstances and also in rheumatic affections of the joints, a light energy less active thermally and more active chemically is indicated. To this end either the energy of solar light or of the electric arc should be used. In muscular rheumatism, lumbago and torticollis, incandescent light energy is of very great value. By its use there is increased elimination of toxic material and the promotion of oxidative processes. In these cases the bath should be given every other day, at first to the point of producing vigorous perspiration and an elevation of the body temperature 2 or 3 degrees. Daily exposures may be indicated in the beginning, but should not be continued so often for too long a time. They should be given from daily to three times, twice or once a week as the case progresses. The general bath should be given from 3 to 5 minutes, or longer, according to the indications in the individual case.

The after treatment in this class of cases should preferably be a cold plunge 65° to 75°F. If this is not available a very excellent substitute may be found in a cool bath or cold towel rub. Again the needs of the individual must be met as they rise. Routine treatment is never successful.

An expenditure of electrical energy will materially aid the progress of this class of cases and may be made by a general application of the magneto-induced sinusoidal, static or high frequency. The two latter are very efficacious and the preference is apt to be given to them, as the clothing offers no obstacle to their use.

The Influence of Incandescent Light Energy in Rheumatoid Arthritis.—Friedlander[1] found that the electric light (cabinet baths) gave better results than Turkish or Russian (steam or hot air chamber) baths. In the treatment of this disease, the two last named are objectionable because

[1]Handbuch Der Physikalischen Therapie, Teil II., Bassel I., Leipzig, 1902.

(1) they with difficulty admit of precise dosage. (2) They have here a weakening effect, and they make a serious demand on the circulatory system.

There is no question but in an expenditure of radiant energy much better results would follow in rheumatoid arthritis than from any other expenditure of thermal energy. Excellent results are secured in these cases from the use of static electricity administered convectively, disruptively or conductively, according to the needs of the individual case. The author believes that the well-known helpful action of the electrical treatment would be enhanced by a preliminary exposure to incandescent light energy. Great care should be taken not to prolong the light bath unduly nor to permit too intense a temperature. The minimum exposure and minimum temperature at which perspiration is induced should be the rule until the patient's toleration is fully established. This the author follows by the electrical treatment as above, preferably to any other physical measure, save the necessary rubbing down (1) with alcohol or (2) with the cold mitten, according to the indications and only for a period of time necessary to thoroughly dry the skin.

The influence of Incandescent Light Energy upon Diabetes.—In this class of patients the author yields the preference to the electric arc because of its deeper and more intensely chemical action. Still there is considerable evidence to show that incandescent light baths are useful and when judiciously used they may take the place of the electric arc, where the equipment affords but the one, just as the exhibition of one drug may take the place of another in the absence of the first. An exception may be made preferably in favor of the incandescent light bath in fat diabetics. They are especially likely to be favorably affected by these baths. Under the powerful stimulation of the light energy, thermal and chemical, the inactive skin becomes active and free perspiration is established. The well-known oxidating action of the light results in an increased oxidation and a lessened excretion of sugar. An increase of the alkalinity of the blood is but a

part of this process, but one that is of value in the correction of this perversion of nutritive action. There may be expected in the average case a relief of symptoms. The after treatment, hydriatic, massage, or electrical, must depend upon the individual case. Prolonged exposure at a considerable temperature should be followed preferably in all cases by cold douching.

The Influence of Incandescent Light Energy in Anæmia and Chlorosis.—Excellent results have been obtained in these conditions by the use of the incandescent light baths.

Save in fat anæmics and chlorotic patients the energy of the electric arc or of the sun is to be preferred because of the greater quantity of penetrable chemical frequencies and their absorption by the blood. In fat anæmic patients the radiant heat bath, by reason of its intense thermal activity, is to be preferred. This class of anæmic cases do not do well until they are rid of their superfluous flesh. Afterwards the progress of such cases should be furthered by the use of the sun or electric arc baths. An increase of hæmoglobin and erythrocytes was observed in anæmic persons by Winternitz after each bath. The more profound effect of the chemical frequencies in producing lasting hyperæmia and pigmentation with a removal of the blood corpuscles from their ordinary course, stimulating the system to replace the blood corpuscle, and the more vigorous carrying on of the metabolic processes renders solar light and electric arc light better in anæmia and chlorosis, and, for that matter, in all conditions involving an alteration of the blood state.

It was noted by Kellogg that the increase in the blood count, red cells especially, in anæmics was permanent where the bath was used daily. The temperature of the bath should not exceed 95° to 104°F. (35° to 40°C.), and the time of exposure should be short, stopping when transpiration begins.

After-Treatment.—A tempered douche, either jet or rain, or a short tepid bath should follow.

Contra-Indications.—There are practically none.

The diaphoresis and the consequent thirst secures the ingestion of considerable quantities of water, which favors normal osmotic processes and facilitates the removal of waste material or toxic agents, which serve to prevent normal oxidation and tissue change.

The Influence of Incandescent Light Energy in Nervous Diseases.—Incandescent baths are reported to have been found useful in a considerable range of functional nerve disorders, but in the author's opinion they are not comparable in this class of cases to the electric arc bath or sun-bath. An exception may be made in favor of the symptomatic neurasthenias where the disturbed nerve function is due to toxæmia or auto-intoxication. Certain hysterias and epilepsies more or less dependent upon a toxic condition should be benefited by their use. They have been widely recommended in neuralgias of all sorts, and for the physician having but the one equipment, can be used in all these functional nerve disturbances, but the preference should be given (1) to the solar energy, (2) to the energy of the electric arc. There is a considerable variety of opinion among different writers as to the value of incandescent light energy in functional diseases of the nerves. By some their good effects are lauded, their soothing effect on general irritability, sleeplessness, singing in the ears, oppression and palpitation of the heart, as noted by Colombo, for example. The difference in opinion doubtless has its explanation in indiscriminative diagnosis. Good results will follow the use of these baths in functional nerve disturbances, which are not essential but symptomatic and due to a toxæmia. Colombo reported excellent results in all vague neuralgias due to the so-called "uric acid diathesis." An essential neurasthenia is not a suitable condition for these baths, but, as has been stated, does well under the influence of the electric arc. Neuralgia and migraine, Kellogg, Strebel and Freund relieved by incandescent light baths.

When used in motor troubles and muscular atrophy, re-education in movement, mechanico-therapeutic gymnastics and electricity should be used in connection with them.

It was observed by Foveau de Courmelles[1] in 1893 that the total white light from incandescent lamps exercised an anæsthetic and calming effect when directed upon the nerve centres, spinal cord, and he used it combined with the static douche in the treatment of neurasthenia. Later the same observer found the incandescent light bath, in which the patient's body was placed, with the head only emerging, an excellent tonic to the spinal cord, and of service in the treatment of myelitis.

In the author's experience a neurasthenic patient, whose condition was complicated by severe spinal congestion, and who suffered not only from insomnia, but from intense pain at the roots of the cervical nerves, had relief from the application of an incandescent light bulb directly over the cervical cord. Sleep without hypnotics was only obtained in this way, the patient sometimes leaving the light burning all night, because of falling asleep under its influence.

The Influence of Incandescent Light Energy in Respiratory Diseases.—Reider[2] states that incandescent light baths afford good results in chronic bronchitis, and in bronchial asthma.

In so far as these conditions are dependent upon the so-called lithæmic diathesis they should be benefited by them. But for all diseases of the respiratory system as such, the electric arc or solar light is preferred.

Cardiac Hypertrophy and Cardiac Dropsy.—The same observer obtained good results in these conditions from the use of incandescent light baths. Kellogg states that in his experience the bath must be used with a considerable degree of caution in this class of cases. The temperature should be

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[1]Report of Light in Nervous Therapeutics, by Foveau de Courmelles, Revue Internationale d'Électrothérapie et de Radiothérapie, Jan., 1904.

[2]Quoted by Kellogg, System of Physiologic Therapeutics, Cohen.

low at first, increased very gradually, and high temperatures always avoided. The heart must be guarded by ice or a cold precordial coil placed in position before the light is turned on. The application should be brief, barely sufficient to induce gentle perspiration. Cold mitten friction should be applied immediately afterwards, and care taken to prevent chilling by exposure after the bath. The cutaneous activity from the action of the radiant heat, with the precautionary measures suggested, greatly relieves the overburdened heart by diminishing the distension of the right ventricle, by lessening the resistance in the peripheral vessels, and by setting at work the "skin-heart," which is often most inactive in those conditions.[1]

In grave cardiac conditions, sun baths or the electric arc bath are to be used preferably, as, for example, in valvular heart disease. The same is true of congestions of the venæ portæ, angina pectoris, and in difficulties of breathing. They are not only more effective, but do not possess the same element of danger for this class of cases as incandescent light energy.

The Untoward Influence of Incandescent Light Energy upon the Heart.—Krebs[2] has observed that it would be an error to believe that incandescent light energy in the form of baths has no effect upon the heart. In almost all cases studied by him he has observed that the profuse secretion of perspiration produces accentuation of the pulse and diminution of the blood pressure, but the increase of the frequency of the pulse in equal conditions of rest was less great than in the bath of superheated air. This is corroborated by Hedley. Although the bath of incandescent light energy is more grateful and better borne by the patient whose heart is feeble, yet Krebs believes it not to be without danger for patients having organic lesions.

[1]Physiologic Therapeutics, Kellogg.

[2]Diaphoresis by Electric Light Baths and Superheated Air. Zeitschrift für Diätetische und Physikalische Therapie, Bd. VI., H. 21, No. 2.

The Influence of Incandescent Light Energy upon Arterio-Sclerosis.—Incandescent light baths, while of much value in arterio-sclerosis, are unsuitable in extreme cases. They should be administered with great care, the heart's action and condition of the circulation carefully watched. If there is not prompt reaction upon the part of the skin, as evidenced by perspiration from the earlier baths, they are contraindicated. The temperature of the bath and the length of the exposure should be governed by the individual case, and also the after treatment. In the author's judgment the minimum temperature and length of exposure are indicated. The condition of the blood vessels must not be lost sight of, their rigidity and inability to accommodate themselves to too intense or too prolonged thermally active energy. After treatment in this condition would better assume the form of an alcohol rub or cold mitten friction. This in turn may be followed to the advantage of the patient by the convective discharge from an excited influence machine.

The Influence of Incandescent Light Energy in Nephritis.—Because of the fact that the incandescent light bath produces abundant diaphoresis without materially augmenting the work of the heart it is of service in all albuminurias. It is not that they affect the cause of the trouble but that they relieve the symptoms which interfere so much with the comfort of the patient. There is, however, prompt relief afforded to the congested and inflamed viscera by the diversion of from one-half to two-thirds of the blood in the body to the skin. These baths, according to Kellogg, may be prolonged for many hours if necessary (the condition of the patient must govern both the length, frequency and temperature), but care must be taken to refresh the patient at intervals by a very energetic cold rub with a friction mitten, by an ice-bag over the heart and by cold compresses to the head. Great care must be taken to avoid chilling. A slight exposure of the body to the influence of evaporation from a moist surface might be sufficient to cause contraction of the blood vessels and counteract the good effects of the bath.

Immediately after the bath, the patient should be wrapped in flannels and preferably placed in bed.

Frequency and Duration of Treatment.—This latter is placed by Kellogg at from 4 to 6 hours and to be repeated in from 24 to 36 hours. Cases of this sort must be guarded against too great an expenditure of energy.

By reason of the fact that incandescent light baths produce but a temporary hyperæmia of the skin and therefore only temporary depletion of the internal organs, they are of less value in diseases of the viscera, where circulatory drainage is necessary, than the more penetrable chemically active energy of the electric arc and of sunlight. Still in their general ability to produce safely profuse diaphoresis the incandescent baths are desirable. When there has been secured copious sweating better results should follow the use of the electric arc bath. The indications for beginning the latter would be the same as for the suspension of other agents used to promote diaphoresis.

By the use of both incandescent and electric arc baths different observers have noted a diminution in the amount of albumen.

Contra-Indications—Uremic Crises.—In conditions of cardiac weakness great care must be taken and the condition of the heart's action carefully watched during the progress of the bath.

The Influence of Incandescent Light Energy in the Toxæmias.—Whether the condition is that of an autointoxication, metallic poison, alcoholism or drug habit there is to be found in incandescent light baths the best possible eliminative agent. There is secured by reason of the profound sudation the ingestion of water in considerable amounts which acts as an internal tissue lavage and by its absorption promotes normal osmotic as well as chemical action. The drainage of the deeper tissues facilitates the throwing off the accumulated residue of toxic material. At the same time the tonic action of the light energy with associated hydriatic measures tends to the establishment of a different fundamental condition on the part of these patients. There is secured a better foundation in the case of alcoholics and drug habitués upon which to build in using specific drug medication.

The Influence of Light Energy in the Toxæmias and Toxic Neuroses.—Nothing can be more important than the fundamental drainage and washing clean, as it were, the organism of all its accumulated impurities. The action of incandescent light energy in this class of cases is illustrated in several of the cases reported by Dr. T. D. Crothers[1] at the 1903 meeting of the American Electro-Therapeutic Association. Crothers, from a series of a thousand baths in toxic neuroses and in the palsies, found them of the very greatest benefit. He finds that they are to be preferred to hot air and vapor baths, which he formerly used for the same class of cases. In the toxic neuroses, under which he mentions the various influenzas and digestive troubles indicated by irritation, depression, headache, irregular heart action and other forms of obscure nerve manifestations, he found the incandescent light baths of the greatest benefit. When associated with appropriate hydriatic measures he finds them of greatest benefit in what he terms the general palsies under which he mentions the neurasthenias, cerebrasthenias, the multiple palsies and defects of the motor and sensory centres, where nerve vigor, force and energy are disturbed and depressed below the normal, also in many of the conditions following a deranged cerebral circulation with defective nutrition, the vaso-motor facial palsies, so common among drinkers, were also favorably influenced, from a modification of the condition to complete recovery. In these anomalous cases, he used in conjunction with the radiant energy of baths the convective discharge from a static machine, mechanical massage, vibration, hydriatic measures, according to the case. Saline waters were administered before the bath when indicated. These cases reported by Crothers are mentioned in

[1]N. Y. and Phila. Med. Journal, July 23, 1904.

this connection rather than under the head of nerve disorders, for the reason that they are the neuroses of toxæmia and as such lend themselves admirably to incandescent light energy. Nerve disturbances not so induced, neurasthenia essentialis and locomotor ataxia, for example, need the chemically active energy of the sun and electric arc.

Case I.—An active business man in middle life suffered from fainting and dizzy sensations following excitement and over-exertion. The heart was hypertrophied and the arterial tension was high, indicating hardening of the arteries. He was given electric light baths daily with hot showers and douches and the static breeze. This treatment was followed by recovery.

Case II.—A business man of alcoholic habits, whose life had been one of great mental strain and worriment, came under his care for asthmatic symptoms associated with sudden depressive heart action. A course of Turkish baths had failed to bring relief, and he complained of dizziness with fluttering heart sensations, for which various forms of alcoholic stimulants were given. The alcohol was withdrawn and the patient put on an active saline treatment. The radiant light bath, followed by showers and douches and constant rest in a reclining position, was given. The bath produced intense prolonged sudorific action with a high surface temperature. In some instances this temperature went up 3 or 4 degrees, but quickly dropped under the influence of showers and douches. The pulse rate declined with each bath and the fluttering heart symptoms disappeared. Later the heart centres seemed to be very greatly disturbed, and as in the morning he complained of chills and cold he was taken to the light bath for a few minutes, being taken out before perspiration began. The regular bath was given in the evening, after which he slept quietly. There was evident toxæmia in this case, indicated by the strong acid odors from the perspiration during the first week of treatment. A static breeze was given every day in connection with the bath. He made a good recovery.

Case III.—A lawyer, 35 years of age, had used spirits for relief from insomnia and the fatigue of overwork for many years. He had been under the care of many physicians, and had taken electrical treatment with a variety of drugs, but had gradually grown worse. Spirits and drugs had been taken alternately for years. After preliminary treatment by salines and the withdrawal of spirits the use of radiant light bath was begun. The perspiration was not very intense at first, but the action of the heart was increased. The temperature dropped from one to two degrees. On each succeeding bath the pulse rate was raised from 10 to 15 beats and the temperature lowered. At the end of a week all drugs were dropped and the bath was given daily. The rest after the bath was very refreshing and increased in duration, until finally he could sleep about 8 or 9 hours. The insomnia passed away and the restoration was rapid and complete.

Case IV.—A physician, 50 years of age, who had suffered a severe electric shock 5 years before had from that time drunk spirits steadily to quiet his nervous system and to promote rest at night. He had an intense fear and dread of electricity in every form and had strong delusions that he would be injured by an electrical current in some unknown way. For some time after coming under care he refused to take radiant light baths, using the hot air bath and receiving the shower and massage afterward. Perspiration was induced slowly and but little change in the temperature followed these baths. He finally consented to take a radiant light bath, remaining in only 3 or 4 minutes at first, just long enough to cause slight perspiration. It was found that his skin was over sensitive to the action of light, and intense perspiration broke out in 4 or 5 minutes after admission with a high surface temperature. The shower afterwards reduced his temperature. The heart's action was raised, but fell quickly from the action of showers to normal. A marked sedative effect followed these baths with the disappearance of the electrical delusion and a rapid improvement mentally. A persistent dyspepsia, which had followed him for many

years disappeared and he recovered and is now at work again in his profession.

Case V.—A medical man, neurotic and a gourmand, had been alternately a drug-taker and spirit-user for many years. At times he would abandon them all and live for months in strict abstinence. He was credulous and had great confidence in drugs and used freely many prescriptions, both proprietary and other combinations. He had taken electrical treatment and had been an inmate of 2 sanitariums without receiving much benefit. On admission he was using paraldehyde 4 times a day and was considered a chronic inebriate. All drugs were withdrawn, and he was given the electric light bath twice a day, remaining in the cabinet until perspiration was very profuse, then taken out, showered and put to bed. The temperature was invariably lowered and the pulse was raised by the bath. Later on the first morning bath was confined to 2 or 3 minutes, while the evening bath was continued 10 or 12 minutes. The surface temperature of the body was 105° and 106°F. after leaving the cabinet, but rapidly went down to normal after the showers. The condition of the arteries improved, and both the bowels and kidneys acted quite freely after the evening bath. Later, the static breeze was given, before the bath and sometimes after. With improved nutrition the nervousness disappeared and restoration followed.

The Influence of Incandescent Light Energy on the Absorption of Exudates.—These baths have been used with good effect upon chronic exudations and effusions. Especially have they been used in France for promoting the absorption of exudates in the cornea of the eye and vitreous opacities. Keratitis parenchymatosa, iridocyclitis, choroiditis and other conditions of a similar pathologic nature are mentioned by Freund. Kellogg states that he has used incandescent light energy with most gratifying success in the absorption of exudates in the pleural and peritoneal cavities, and in and about the joints. From their general and local use combined with appropriate hydriatic measures, absorption of

exudates in and about joints is rapidly stimulated, and the author questions if there is a better means to the end. The treatment of joints need not necessarily be confined to incandescent light energy. On the other hand, the electric arc with a parallel beam converged to a focus on the affected joints in long-standing processes should yield better results. In this way not only the necessary thermal energy is provided, but an intense chemical energy as well of great penetrating power.

Contraindications.—Contraindications are found in organic heart disease, and marked congestive symptoms, in phthisis with night sweats (the author advises the use of the electric arc or of sunlight in all cases of phthisis, and never under any circumstances uses the incandescent light in this class), in hemorrhagic cases, hæmoptysis, hæmatemesis, apoplexy, and in all cases where no perspiration results from the earlier baths.

Other contraindications may be found to exist either in other pathological conditions or in individual cases, the rationale of which will appear from the fundamental principles of the action of incandescent light energy in connection with physiological action, and its relation to the especial pathological manifestation.

CHAPTER XI.

The Concentrated Visible Chemical Frequencies of the Solar Spectrum. Mechanisms, Methods of Use and Therapeutic Indications. Malignant Pustule, Diphtheritic Croup, Pneumonia, Pulmonary Tuberculosis and Lupus Vulgaris.

The Concentrated Visible Chemical Frequencies of the Solar Spectrum.

In the visible chemical frequencies of solar light there are to be had in great abundance the very penetrating and valuable blue-violet frequencies. These, when concentrated and used in such a manner as to eliminate in part the intense thermal energy of solar light, can be used in a considerable variety of morbid conditions. In fact, they are useful in every condition to which light is applicable, but not as useful in deep-seated localized skin conditions, lupus vulgaris, for example, as the electric arc light, because of the slight chemical intensity in the ultra-violet region at the earth's surface, as compared with that artificial source of light, and also because with a simple convex lens, not only the light energy but the thermal energy as well is gathered into a focus. In this focus so high a temperature is generated that it is simply impossible to expose living matter to it for any length of time. It is only necessary in this connection to recall one's youthful experiences with the burning glass for the purpose of ignition; or, to still further emphasize the fact of this intense thermal energy, to instance the burning of the vessels of the Romans before Syracuse by Archimedes.

The Use of a Parabolic Mirror to Prevent Undue Heating.—It is noted that as the red or thermal frequencies are less refrangible than the frequencies above the red, they may

be eliminated to a certain extent by means of a parabolic mirror. For this purpose only the reflected rays of the sun, not the direct as per the method of Finsen are used and these refrangible rays are condensed and focussed on the patient in the usual way.

Concentrated sunlight is obtained by using (1) convex lenses, or (2) concave mirrors.

Many years ago the burning glass was used for the purpose of concentrating sunlight upon the affected part. From its use in this manner good results were obtained. In connection with such use there may be mentioned the names of Butler,[1] Thayer, Mehl, Piffard, and a layman mentioned by Otterbein.[2]

Willard[3] states that within his recollection Butler in the sixties, some 40 years since, successfully employed sunlight for the treatment of epithelioma using for the purpose an ordinary biconcave lens.

Piffard[4] is authority for the statement that he employed sunlight, concentrated by means of a glass lens, about 25 years ago, for the treatment of a few cases of lupus. By this means the lesions were simply burned out, as in concentrating the light of the solar spectrum by a glass lens, the thermal frequencies are extremely active. Every one is familiar with the action of concentrated sunlight through a glass lens in the ignition of inflammable material. This action was the same in Piffard's original work, as there is no mention of any filtering arrangement for the exclusion of the thermal activities, as in the case with the hollow lens filled with a solution of sulphate of copper as used by Finsen.

The Sun Lens as Used by Finsen.—The solar condenser, as devised and used by Finsen at his institute in Copenhagen, consists, first, of a hollow plano-convex lens, 25-30 cm. in diameter, with a focal distance of 60 cm. It has a capacity

[1]Quoted by Willard, Sunshine vs. X ray, Jour. Am. Med. Ass., July 18, 1903.
[2]Quoted by Finsen.
[3]Ibid.
[4]N. Y. Med. Record, March 7, 1903.

of about 2 liters, and was filled with an ammonical solution of cupric sulphate. The object of the copper solution is to absorb not only the thermal frequencies, but all save those having the same refrangibility as the corresponding color of the spectrum. This lens is mounted on a foot in such a way as to enable the operator to give it a vertical, horizontal, as well as an up-and-down movement at will. All the frequencies then from the edge of the blue to the ultra-violet region, none less than 30 microcentimetres, however, in passing through this lens are condensed, and focussed at a point of about 60 cm. from it. In this way there is provided a greatly condensed luminous sheath of practically pure chemical frequencies other than the ultra-violet.

These frequencies are possessed of a germicidal action, as is shown by the action of sunlight on bacteria and upon polluted streams.

The Purely Bactericidal Frequencies not Present in Condensed Solar Light.—The purely bactericidal region as shown by the experiments of Bernard and Morgan, however, is not present for two reasons: (1) That but few of the short high frequency waves of light, ultra-violet are present in sunlight at the earth's surface, because of their absorption by the atmosphere, and (2) the glass of the condensing lens effectually absorbs such as there are. A lens so filled with cupric solution does not completely eliminate the thermal activities, and it may be necessary, therefore, to have a second lens, which is used as a compressor to dehematize the tissues, also made hollow with two canulæ, one afferent and one efferent, in communication with the cavity. Through this a current of cold water was kept constantly passing. Because of the prolonged exposures necessary with condensed sunlight in the treatment of organized skin conditions, the solution in this second lens also becomes hot.

W. H. Dalphe[1] states that with this second heat filter, he

[1]W. H. Dalphe, B.A., M.D.: Light as a Therapeutic Agent, lecture delivered to the students of the class in Pharmacology and Therapeutics, University of Bishop's College, Faculty of Medicine, Montreal, March, 1903.

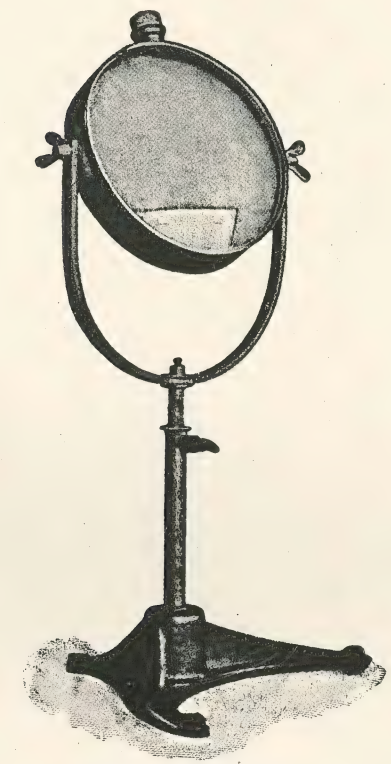

Fig. 15.—Sun Lens.

has been obliged to interrupt his sittings and that through it he could set fire to paper or cotton goods in a very short time.

Methylene blue is sometimes used in the large hollow condensing sun lens as a filter of the longer slower frequencies below the blue. A solid lens, with or without a blue glass filter, may be used, either in connection with a circulating water glass filter, which is independent of the lens, or without it.

Photographic Ray Filter for Concentrating Solar Light.—Kime[1] used a modification of the ray filter employed in photography, with an 18-inch focus. At the focal point it is intensely hot, but he found that in some cases nothing short of this intense heat established reparative processes. This was by reason of the fact that both the source of light (sun) and the means used (glass) absorb the very valuable and more intense chemical frequencies, ultra-violet, so necessary in combination with the blue-violet in establishing tissue reaction and securing the regressive and productive tissue changes essential to the reparative process. In his work he utilized a beam of sunshine one foot in diameter, which fell through the office window upon the sun glass, the hollow chamber of which was filled with a solution of sulphate of copper for the purpose of absorbing the frequencies below the blue.

Not all of the Component Parts of White Light can be used with a Sun Lens.—Once more in this connection it may be reiterated that none of the ultra-violet below 30 microcentimetres can pass through the glass. A still further influence is exerted by the liquid in the filter, weakening the intensity of such chemical energy as is otherwise obtained from the ultra-violet region of greater wave length as it borders on the blue-violet. The experiments of Bernard and Morgan upon bacteria may be referred to in this connection, as showing that four-fifths of the bactericidal energy is ab-

[1]Kime: Light in the Treatment of Lupus and Other Chronic Skin Affections. Journ. Am. Med. Ass., April 11, 1903.

sorbed by passing through 2.5 cm. of water. There is still further absorption by the addition of methyl blue or an ammoniacal sulphate of copper.

Ultra-Violet not Transmitted through Quartz Containing Chamber when Filled with Ammonia-Copper Sulphate Solution.—Under proper conditions of experiment, i.e., with a quartz containing chamber for the ammonia-copper sulphate solution, 5%, through which the beam of light is allowed to pass upon examination by means of a grating spectroscope, it is shown that blue, indigo and violet frequencies pass, but practically no ultra-violet. However, as with the glass containing lens, the ultra-violet are cut off in any event, the blue filtering solution does not interfere with the residual energy of the visible chemical frequencies of the spectrum.

Were it practical to have sun lenses made of quartz, then by filling them with uncolored water there could be obtained a greater proportion of the non-absorbed (i.e., by the atmosphere) of the ultra-violet frequencies than with a blue filtering fluid. But because of the scarcity and expense attendant upon the quartz lenses, this is not practicable. It is clearly shown in these pages, however, that valuable as the ultra-violet frequencies are (1) in bactericidal power and (2) ability to excite tissue reaction, they are not absolutely essential to the obtaining of therapeutic results in skin conditions. Finsen's early work with the sun lens was demonstrative of this fact. If ultra-violet energy be of low intensity, it is absorbed by the surface layers of the skin, but if of higher intensity, a violent inflammation of the skin is produced. See Action of Light Energy Upon Skin, Chapter VII.

This intensity of ultra-violet light energy is such as is obtained from iron electrode arcs, for example the original Bang lamps, or those modelled by it.

The Complex of Chemically Active Light Energy Produces the best Results.—Under the use of the concentrated chemical frequencies of the electric arc it is clearly pointed out that the penetrant blue, indigo and violet frequencies are

factors of great importance where deep-seated processes are to be acted upon, that their presence is more necessary than the ultra-violet, but that, after all, it is the complex of chemically active light energy which is capable of producing the best results.

If the thermal energy is sufficiently eliminated by the filtering arrangements for that purpose, it is not possible to produce so intense an inflammation upon the healthy skin with concentrated sunlight as with the electric arc, by reason of the absence of the ultra-violet.

In the adjustable photographic ray filter used by Kime there is at the focal spot intense heat which produces a strongly irritant action upon which he depends for the excitation of the necessary reaction, i.e., the production of hyperæmia inciting in its turn new vigor, new cell action, and subsequent reparative processes. This action is due to the combined influence of the concentrated thermal and chemical energy.

Concave Mirrors for Concentration of Solar Light.—A greater quantity of light can be concentrated by means of concave mirrors than can be done by lenses. Kime has utilized this fundamental principle in the construction of his sun room at Denver for the treatment of tuberculosis pulmonalis. Strebel also uses metal reflectors one metre, 39.5 inches, in diameter but with a water-cooling arrangement in front of them.

Technique.—The technique with the sun lens is the same so far as preparing the lesion for exposure as with any source of light, viz., freeing the diseased surface from crusts. In addition, in Kime's work the part was washed with water, but no antiseptics were used. This is a matter which varies with the individual operator. The light is moved over the tissues, coagulating the albumin in the tissues, until it is of a smoky white color. The light is used at the focal point for this, and the action desired is secured in a few minutes. This application should always be made by the physician himself, but afterwards for the subsequent

and prolonged application of the light, non-focal, it may be left in the hands of the nurse or office attendant, who continues the application for 10 minutes longer. A wet dressing is then applied, to be removed the following morning, when a 20-minute exposure is made at the non-focal point of the condensed light. On the third day Kime uses the light again at the focal point upon any part which has failed to respond to its irritative influence. The parts are thoroughly cleansed twice a day. In his monograph on the subject Kime submitted four photographs showing most excellent results.

Recapitulation.—Treatment with a sun lens while capable of securing extremely good results, is not so good as with an electric arc.

The concentrated visible chemical frequencies of solar light energy are useful in all of the skin conditions in which the electric arc has been found to be of service as set forth in Chapter XII., The Concentrated Chemical Frequencies of Electric Arc Spectra. The difference in effect is in degree not kind, and when the thermal energy of concentrated solar light is sufficiently eliminated from the latter, it is difference due to the greater proportion of the ultra-violet in the arc; a difference which is, however, compensated for to a considerable extent by the richness of the solar spectrum in the blue-violet frequencies.

Concentrated chemical solar light energy can also be used in suppurative and septic processes, as can the electric arc. It is a question only of the flexibility and adaptability of the means to the end. Experimental work and clinical evidence suggest that it is not as good in syphilitic lesions as the concentrated chemical energy of the electric arc. The same use of solar light which happily cured a tubercular laryngitis as quoted, failed in a case of syphilitic laryngitis. It is quite possible the author believes that the same happy result would have followed the use of a source of light rich in ultra-violet frequencies in this case. This point is fully elucidated in discussing the treatment of syphilis under the

concentrated invisible chemical frequencies of the spectrum or ultra-violet light energy (Chapter XVI.).

The literature of the therapeutics of concentrated and condensed chemical solar light energy is not as rich as that of the therapeutics of artificial sources of light, but the individual operator in possession of a sun lens will find that in practical work he may closely approximate by its skilful use the results obtained with the electric arc.

Treatment of Suppurative Keratitis by Solar Light.—Among those who have experimented with the sun lens may be mentioned E. Nesnamow.[1] His experiments were upon artificially provoked suppurative processes in the cornea. He used a concentrating lens similar to Finsen's, of 8 diopters and 10 cm. in diameter. Care was taken to exclude the thermal energy. Five severe ulcers of the cornea were treated for 2-5 minutes daily with the blue-violet frequencies of solar light with excellent results. To exclude the thermal energy Nesnamow filtered the light through a layer of water colored with methyl blue.

Concentrated Chemical Solar Light Energy in Tubercular Laryngitis.—M. Romme[2] quotes a report of M. Sorgo to the Society of Internal Medicine of Vienna, in which the latter reports the case of a patient with well-characterized tubercular laryngitis. He concentrated solar rays, by means of the laryngoscope, upon the ulcerated mucosa of the larynx. At the end of 30 séances of this laryngoscopic phototherapy, of which each had a duration of about an hour, the vocal chords had recovered their normal color, and the tubercular ulceration was cicatrized.

The healing of a tubercular laryngeal ulcer was established in the author's experience in two weeks without any direct application of the light activities. In this instance,

[1]Westnik Ophthalmologie, 1901, Jan. and Feb. cf. Dworetzky Zeitschr. s. diät. u. Phys. Th., Vol. V. Part III., also Amer. Med., May 31, 1902.

[2]Desiccation and Phototherapy in the Treatment of Granulating Wounds, by M. Romme.

Revue Internat. d'Électrothérapie et Radiothérapie, Jan., 1904, abst. from Presse Medicale.

however, the electric arc was used, giving the maximum of ultra-violet energy. In the latter there are available many more of the intrinsically valuable chemical frequencies, and as a source of light it is much more flexible and amenable to control than sunlight. The latter is uncertain, not only hiding its radiant energies oftentimes when needed, but also because of one's inability to control the position of the beam of light, and hence its focal point in a sitting of any length. Often, at least an hour is required for a sitting, and this means constant attention on the part of the physician or his assistant, as the lens will have to be continually moved, vertically, horizontally and up and down. It is a tax upon the physician's time and the patient's endurance and patience. But in the absence of a source of E. M. F., rendering it possible to use an electric arc, it is eminently worth while. Its advantages conpensate for its disadvantages. It is portable, can be used at a patient's house, as well as at the physician's office, and is well adapted to a country practice. In latitudes where the sun is but little obscured by clouds, as in the more southern climes, it is pre-eminently useful.

In this field Kime has been an indefatigable worker, a brief résumé of whose methods and results in the use of concentrated chemical solar light energy (1) by means of the sun lens in skin lesions and (2) by the use of reflecting mirrors in tubercular pulmonary lesions is given.

The Concentrated Energy of the Visible Chemical Frequencies of the Solar Spectrum in the Treatment of Lupus and Other Chronic Skin Affections.—Kime[1] prefaces a report of a series of cases treated by means of solar light energy, and the manner of its use by the statement that "light and especially concentrated actinic light derived from the sun, is a specific in the treatment of lupus, chronic ulcers, and other destructive lesions of the skin."

The Concentrated Energy of the Visible Chemical Frequencies of the Solar Spectrum in the Treatment of Pulmonary Tuberculosis, Concentration by Means of Mirrors.—Kime has also contributed two very valuable papers upon this subject. In the last[1] one, after calling attention to the physical characteristics of light energy and its physiological action, he gives the following description of his method for utilizing sunlight in pulmonary tuberculosis: A concave reflector, 36 inches in diameter, overlaid with blue glass, focuses a strong blue light upon the surface of the chest, made bare for two hours each day. This light is sufficiently strong to thoroughly illumine the lungs. Patients thus treated (using all other adjuvants of known value in the treatment of tuberculosis), Kime finds respond more quickly, and a greater percentage of recoveries takes place than under any other method of treatment with which he is familiar. Even cases far advanced begin to show improvement almost immediately, and from his experience he is convinced that but few cases in their earlier stages may not be permanently arrested. This statement is made from a personal experience of a number of years, and is based upon a sufficient number of cases to warrant its truth.

Since his first report Kime has removed to Denver, where he has a maximum of sunshine. There he has his skylight constructed of blue glass, but the reflectors are not overlaid with it.

The following is the order in which improvement occurs: loss of chills and night sweats; gain in body weight; increased appetite; lessening and disappearance of diarrhœa if it is present; increased strength, as a rule, rapidly, and ability to walk considerable distances as against short distances before; diminishing cough without the use of medicines; declination of febrile conditions in from a few weeks to 2 months or more, and after 2 or 3 months a return to the normal, where it remains. Bacilli are almost the last evidence of the disease to disappear, as they were also the first factor in the production of the disease. Frequently patients

[1]The Journal of the American Medical Association, April 11, 1903.

[1]New York Medical Journal and Phila. Med. Journal, April 30, 1904.

leave the sanitarium with bacilli still remaining, and when they return a few months later the bacilli are found to be absent from the sputum.

The concentrated energy of the solar spectrum does not seem to have been availed of to such an extent by any one person as by Dr. Antonio Sciascia. In his published work Sciascia[1] used an instrument of his own device to which he gave the name of *Fotocauterio*. His instrument is designed for the condensation of the chemical and thermal energy of solar light. The lenses are of glass, biconvex, therefore, so far as the chemical energy is concerned, it is the visible chemical frequencies only which are used. But as few invisible or ultra-violet frequencies are available in solar light it does not so much matter. By the use of different sized lenses, from 1 to 4 ccm. in diameter, areas of varying size were treated, and by the interposition of different colored glasses, the energy of one part or another of the spectrum was used at will. It is also capable of regulation as to focal distance so that the focal spot may be used near to the apparatus or projected at a greater distance, according to the condition to be treated. Because of the wide and unusual range of diseases subjected by Sciascia to the action of solar light energy, the care with which his cases are reported, and the results obtained the author has thought best to introduce them into this text to stimulate and guide others in their work.

There is found in a personal experience corroboration of much of Sciascia's work. To secure the same results requires an intelligent, skilled and patient use of the energy of solar light, with which southern climes especially are so bountifully provided by nature.

From 1890 to the present time Sciascia has been able to record 28 cases of malignant pustule, more or less serious, all cured by the action of light energy. The following cases are types of the series:

[1]La Fototerapia. Roma. Société Editrice Dante Alighieri, 1902.

Malignant Pustule—Case I.—A. C., 28 years old, a shepherd of sound constitution; has had no sickness worthy of note.

Presents a pustule upon the left cheek, dating about 4 days. In the centre of the same is a necrotic area, 3 millimetres in diameter, surrounded by a number of vesicles of various sizes (from a hemp seed to a pea). The cutaneous tissue which surrounds the pustule is in a condition of acute tumefaction, which extends to the boundary of the face and on the neck, as far as the supra-clavicular fossa of the same side. Several days before he fell sick he had skinned a sheep dead of carbuncle. About the third day of his sickness he became feverish. He was sick and livid, prostrated with fever—T. 39°C. P. 120, R. 42. The local lesion tended to diffuse with rapidity, causing an impairment of the general condition.

Treatment—First day.—Exposure for one hour of the diseased area to the concentrated and condensed energy of solar light. (The thermal energy was utilized as well as that of the visible chemical frequencies.—The author.)

During the luminous projection the rupture of the vesicles begins with the discharge of a turbid whey, and the vascular cutaneous rete becomes swollen; by degrees the more delicate capillary vessels dilate, the swollen cutaneous tissue from livid becomes rosy, and begins to exhale a moist vapor, visible to the naked eye, with gradual reduction of the swelling, the local pain is relieved, and the temperature is diminished.

Second Day.—An eschar is noticed at the necrotic point, it extends but more superficially at the site of the vesicles destroyed the preceding day. At the periphery of the new necrotic area are seen some new phlyctenules much smaller than the former. The swelling is much reduced, the pain relieved, the fever reduced. The action of the second application of the solar energy is the same as on the preceding day.

Third Day.—A limitation of the eschar is noticed; no

appearance of new vesicles. The carbuncle-like swelling is much reduced, less pain, no more fever. The action of the third application was like that of the preceding. The exposures were repeated for 10 more days, at which time repair had taken place with disappearance of the eschar. A small unnoticeable scar remains.

Case II.—A woman, 60 years old. In addition to having a lacerated contused wound upon the forehead is reported to have handled the flesh of animals dead of carbuncle. After 10 days a malignant pustule appeared in the same locality as the wound, appearing like a scar.

Clinical Report.—On the pre-existing wound is observed a gangrenous eschar, with some small carbuncle-like vesicles at the periphery, full of a turbid, bloody whey; the face is invaded by œdema; acute pain is experienced especially in the left orbit-palpebral region near the pustule. The patient is feverish, T. 38.5°C.

Treatment—First Day.—Deep cauterization of the pustule with the solar energy.

Second Day.—The patient is without fever; the local inflammation is much improved; the carbuncle-like eschar is limited, the vesicles entirely destroyed.

Third Day.—The improvement of all the symptoms is progressing; the necrotic crust begins to separate at the periphery, and the action of the light energy is like the preceding day.

Four more applications of condensed white light, Tem. 50°C. on alternate mornings are sufficient to produce a definite cure.

Case III.—A shepherd, aged 40, presents a carbuncle-like eschar on the left forearm, dating since 7 days, of round shape, diameter 2 cm., with some small phlyctenules near the periphery. The inflammation extends through the entire arm, the axillary lymphatic glands of that side are swollen and painful. Patient is feverish, Temp. 38°C.

Treatment.—One deep cauterization with concentrated solar light, at the maximum degree of temperature on the

malignant pustule was sufficient, with a daily application of white condensed light, T. 50°C. and a complete cure was obtained in 20 days.

Case IV.—G. G., 18 years old, shepherd. No previous illness. Ten days after he had skinned a goat dead from carbuncle, a pustule developed below the left labial commisure, where a small ulcer pre-existed. He treated the matter as though it was nothing, neglected to consult any physician, although by the fourth day he was feverish. Nevertheless he waited two more days, "trusting to the help of nature."

On the sixth day he came under observation for the first time, and was in a "condition of great embarrassment."

The pustule is surrounded by phlyctenules of various sizes. In the centre is a necrotic area of the diameter of a centesimo (the coin equal to the size of an old-fashioned American cent), which invades the entire thickness of the tissue as far as the oral cavity. The swelling is acute and painful to pressure, extending over the face and neck. The oral mucosa which surrounds the eschar begins to resent the spread of the process. The patient is cyanotic, drowsy, in a state of collapse, with cold extremities. The respiration is stertorous, pulse almost imperceptible, T. 36°C.

Treatment—First Day.—In a dangerous condition, and a fatal result imminent, it was therefore necessary to have a recourse to more energetic medication than usual, namely, photo-cauterization of the pustule and to make a distribution within the carbuncle-like seat of inflammation of the vapor of iodine, to impress with more facility the auxiliary therapeutic action of the iodine and to push the iodine in a gaseous state through the circulation. Moistening then the pustule with iodine, an application was made with the photo-cautery, which allows the maximum concentration of solar light to the moistened necrotic eschar, to an area of half a centimetre. A sufficient temperature was used to cauterize the pustule deeply, and to vaporize the iodine. The rupture of the phlyctenules with the discharge of a turbulent san-

guinolent whey was also produced. The alimentation is by rectum, consisting of milk, eggs and coffee.

Second Day.—The patient responds to all questions; can swallow, his pulse is somewhat raised, T. 39.3°C. The eschar extends less deeply, as far as the site of the destroyed vesicles; the swelling, redness and pain are much reduced. The application of chemical condensed light for an hour obviates the necessity for further photo-cauterization. During the luminous projection the patient noticed a local comfort with relief of the pain.

Third Day.—No fever, everything is relieved. The necrotic tissue is beginning to detach at the periphery. The action of the usual application is the same until the 10th day, when there is a detachment of the necrotic tissue. A sinus remains which communicates from the outside with the oral cavity, the borders of this are granulating. With the continuation of the light energy until the 20th day there was the healing of the sinus and the small cicatrix seen in the photograph. These 4 cases are photographically illustrated in the original, pictorially vouching in every instance for the result obtained.

Pertussis.—Dr. Sciascia has also recorded 60 cases of pertussis, 50 children and 10 adults, all cured by the use of condensed light energy. He has observed that the condensed light acts as an antispasmodic and shortens the duration of the illness. Two illustrative cases are given:

Case I.—S. G., 3 years old, is harassed with pertussis in the convulsive period. It was the 15th day of the disease. The prodromic period occurred with fever and symptoms of simple bronchial catarrh, lasting for 10 days.

Clinical Report.—The child is without fever, hoarse, panting, with swollen face and ecchimotic spots under the conjunctiva. The crises of the convulsive cough were in classical form, occurring 12 to 16 times in the 24 hours. They were of long duration with frequent vomiting. The nose was filled with a thin sanguinolent liquid; the mucosa of the vaso-pharyngeal-epiglottic cavity was hyperæmic; in

the right supraclavicular fossa were felt nodular kernels of various sizes which extended deeply near the thoracic organs.

Treatment—First Day.—Application of chemical condensed light, in an area which uniformly irradiated the face, the neck and the chest, producing an abundant sweating and frequent sneezing with epistaxis. The child cried under the stimulating influence of the condensed light, and this penetrated the pharynx without the need of a tongue depressor, producing a hypersecretion of the thin mucus.

Second Day.—Nothing new is observed. Exposure to the light energy is repeated for an hour, as on the preceding day, producing the sweating and sneezing without epistaxis.

Third Day.—A great amelioration was observed. The crises of the pertussis begin to be more rare, and without vomiting. The same method was continued for 8 more days and a definite cure of the pertussis and the resolution of the engorged glands was obtained.

Case II.—A girl of 10 years was brought in after 20 days of the sickness, harassed with an obstinate pertussis with grave symptoms. The prodromic period was about 10 days, with fever, and simple bronchial catarrh. The physician had exhausted the arsenal of rational pharmaceutics without result.

Clinical Report.—The child is anæmic, ill-nourished, sunk in a profound languor, tending to inanition. The fits of convulsive cough are in classical form, frequent and of long duration. The naso-pharyngeal-epiglottic mucosa is hyperæmic, with adenopathy of the right cervical region extending to the supraclavicular fossa of the same side.

Treatment.—Application of chemical condensed light in the pharyngeal region, with the tongue depressed, which produced an abundant secretion of mucus, and profuse sweating. An application of the same strength which included the face, the neck and the anterior part of the thorax was made for an hour. After two days a cessation of vomit-

ing, a mitigation of the fits of convulsive coughing with an amelioration of the other symptoms was noticed. Eight other sittings were sufficient to produce a complete cure of the pertussis and the resolution of the engorged glands.

Tuberculosis.—In several forms of tubercular lesions, the results were excellent.

Lymphangitis Tuberculo-Gummatosa.—G. S., 18 years old, with positive hereditary antecedents. She had a torpid nodular swelling at the articulation of the left elbow. She had trusted for her treatment to the ill-advised exercises of a poor ignorant woman of her country, a serious maltreatment complicating a phlegmonous, suppurating periarthritis, which opened spontaneously on the external part of the articulation with a discharge of pus and caseous detritus, according to the report of the attending physician. At that time there was left an incurable opening.

Clinical Report.—The disease dated from 7 months. The young woman was emaciated with fever. She presented a torpid ulceration at the articulation of the left elbow, antero-external region, periarticular, extracapsular with flabby edges, thick and full of lumps and with different subcutaneous sinuses which extend to the middle of the forearm. The morbid process tends to spread in the periphery and deeply. Moreover, at the lower part of the sternum in the vicinity of the Xiphoid appendix a little to the right is observed a tuberculous gumma, the size of a dove's egg, which is beginning to soften. The overlying skin is reddish and tends to thin out.

Treatment.—To fill up the ulcerated cavity at the elbow with a powder of iodine mixed with potassium iodide, and with the photocautery project the maximum concentration of the sun's rays to heat the powder of iodine, producing an azure light with the developing of iodine vapor while deep cauterization occurs.

The tubercular gumma on the chest was treated with the photocautery, until the production of an eschar. This detached itself after the second day with discharge of a thin

yellow liquid mixed with caseous detritus. Then the cavity was filled as usual with powdered iodine, which was treated by the photocautery to produce a deep cauterization down to the sound tissue. This operation was repeated 3 times with an interval of 20 days, besides 20 sittings with chemical condensed light. After 3 months the cure was complete. The articulation of the elbow remained unhurt. At the end of 5 years it has not relapsed.

Tubercular Poliadenitis.—V. M., 10 years old, with bad history. Presents a chain of glands which occupies the right cervical region to the supraclavicular fossa of the same side. The glandular kernels are of various sizes, from a pea to an almond; some are swollen, others caseous or ulcerated. The morbid process tends to spread with the appearance of new glandular nodules of the same kind in the neighboring organs. The general condition shows a progressive wasting.

Treatment.—Local application of an area of chemical light for an hour a day. Sixty sittings are required to obtain a cure.

Observation.—The glands in the condition of simple inflammatory swelling came to full resolution; those that suppurated became caseous and ulcerated. On account of the cicatrization they are destroyed and eliminated more slowly by a natural work of a morphological process, in the same way as the eliminations of tuberculosis and lupus.

In 12 other individuals affected with the same disease Sciascia obtained the same result.

Tubercular Peritonitis.—M. L., age 9 years. Etiology positive, was a case of tubercular peritonitis treated successfully by means of concentrated light energy. The patient, a child, presented the classic symptoms as well as typical physical signs. There was anæmia, ascites, enlargement of the abdominal lymphatic ganglia, vomiting, anorexia, vague abdominal pains, intestinal disturbance, scant urinary secretion with trace of albumin.

A general application of the light was made to the entire

abdominal and thoracic region for an hour on alternate days. Gradually after three months there was resolution of the ascites and enlarged lymphatic ganglia, with improved nutrition. After five years the patient was still well.

Pneumonia.—In 12 cases of croupous and catarrhal pneumonia, good results are reported. A typical case is the following:

Lobar Pneumonia.—D. N., a countryman 40 years old. Presents a pneumonitis of the superior lobe of the right lung dating from 4 days, with general symptoms of adynamia. Upon auscultation is heard an accentuation of bronchial breathing, upon percussion an area of dulness is discovered in all the region of hepatization of the lung; the cough is frequent with difficult expectoration of a prune-colored secretion. T. 40°C., P. 130, R. 40; the urine is loaded with urates, and contains albumin, the compensatory respiration is impeded by collateral œdema.

Treatment.—Daily applications of chemical light in the right region of the thorax for half an hour; afterward provoking the nasal reflexes with the thermic light energy, T. 52°C., to facilitate the expectoration through the reaction upon the "fibroid cellules of the lung." By the third day the hepatization begins to resolve, the crepitant rattling to return, heard in the posterior part. The cough is less frequent with easier expectoration. The fever is less. T. 38°C., and the collateral œdema has disappeared. At the fourth sitting, after the crisis of a copious sweating the defervescence of the fever occurred and complete resolution of the pneumonitis. There remained during the convalescence a mild pulmonary catarrh, which was not of long duration.

Diphtheritic Croup.—Six cases were treated by the condensed light energy, with recovery.

Descending Diphtheritic Croup.—V. L., 5 years old. No previous sickness worthy of note.

Clinical Report.—The sickness has lasted 3 days with fever, malaise, pain in the throat, and difficulty in swallowing. The mucous membrane, which covers the tonsils and palate, is covered with false membrane, the nose discharges a yellowish serum, sometimes bloody; the neck is invaded by a swelling; the urine contains traces of albumin. On the fourth day a hoarse cough developed with progressive restlessness and shortness of breath.

On the fifth day there was dyspnœa, suffocation, supraclavicular depression on inspiration and threatened asphyxia with an imperceptible pulse.

Treatment—First Day.—Application of chemical condensed light to the naso-pharyngeal-epiglottic region, causing a hypersecretion of mucus to facilitate the elimination of the false membrane, reduced to a pulp by the action of the light. There is sneezing with epistaxis. In consequence of the sneezing and the sweating the respiration becomes freer, and the general symptoms are relieved.

Second Day.—The false membrane is not reproduced, the fever is milder, the cough is less; the circulation and respiration improved, and the glandular engorgement tends to resolution. Six other applications of the light energy were repeated on alternate mornings, gradually producing a cure. A slight degree of hoarseness and a catarrhal cough remain for two weeks. Six other cases of equal seriousness were treated with the same method, recovering in longer or shorter time.

Nervous Diseases.—In chorea minor, Dr. Sciascia has treated 20 cases with success, 16 girls and 4 boys, from 6 to 15 years old. Neuralgias and hysteric conditions are also reported as cured. Typical cases are given in detail:

Chorea Minor.—A. C., 13 years old, a peasant.

After prodrome of the disease with psychic disturbance he was taken with incoördinate, involuntary movements, especially on the left side.

Clinical Report.—The sickness dates from 6 months. Shows irregular motions of the head, of the muscles of the face, and of the limbs; sometimes a contraction of the extensors, at other times a flexion and raising of the shoulders.

The patient is not able to stand on his feet on account of the manifold incoördinate movements, which complicate 3 or 4 groups of muscles in different regions at the same time, and cannot be controlled by the will. He stammers and slights his vowels, and eats with a convulsive motion. Sensibility to heat and pain is diminished in the left lower limb.

Treatment.—Application of an area of chemical condensed light which includes uniformly the head and vertebral column for an hour, producing a copious sweating, and relief from the spasmodic action. Ten other applications were sufficient to obtain gradually a definite cure.

Sciatic Neuralgia: Basedow's Disease.—M. C., 37 years old, multipara, of weak constitution, habitually neurasthenic.

For 6 months she has been harassed by pain in the left side. At first it prevailed principally in walking, now it is insupportable during repose.

Clinical Report.—Presents exophthalmia, hypertrophy of the thyroid and tachycardia. The pain is paroxysmal and obstinate in the left thigh, accentuated during the night with phenomenal intensity. The points of pain are sacro-iliac, trochanteric, popliteal and malleolar. Lasègue's sign exists.

Treatment.—Every kind of medical treatment had been employed "with discernment" in the treatment of the sciatica without result.

First Day.—With the solar energy the work of cauterizing *trascorrente* (running over), according to Valleix, for the first time, and then the daily application of chemical condensed light of a uniform area, which comprehended the left lumbar, popliteal and malleolar regions for an hour, alternating the thyroid body and the cervical ganglion of the sympathetic.

Every application produced copious sweating with progressive alleviation of the pain, gradual decrease in the paroxysm until the thirtieth sitting; after that she had a definite cure of the sciatica and a relief of the cardiac symptoms depending upon the Basedow's disease.

Tic Douloureux.—I. C., 57 years old, healthy. For 4 months he was affected with an acute pain, spasmodic and insupportable in the lower part of the left cheek in the labiomental region.

During the attack every slightest movement in speaking and chewing, or the lightest touch upon the point of pain, was impossible. No movements or other manœuvres occurred in the intervals of pain. The objective examination shows that the seat of the trouble is in the third branch of the trigeminal nerve, at the exit of the inferior dental nerve. The cause of the hyperalgesia is the irritation of the mental plexus and the fibres of the facial which cross it, resulting in the clonic muscular contractions which complicate the neuralgia. The spasmodic pain is acute, frequent and rebels against all pharmaceutical treatment. Neurectomy is advised. For this the eminent surgeon, Dr. Carlo Gangitano, Professor of Clinical Surgery in Naples, was called. Before he intervened and the last resource was exhausted, the patient was sent to Sciascia's Institute for Phototherapy.

Treatment.—One the first day the photocautery, i.e., thermic solar energy for the work of "passing over" (*Trascorrente*) cauterization according to Vallei, in the painful region of the inferior dental nerve was used, followed by the projection of a chemical condensed light over the spasmodic zone for an hour. This produced a profuse sweating and a general sense of well being. The spasms returned during the day with the same intensity, but less frequently. On the second day there was no need of photocauterization. With the repetition of the light chemical condensed treatment of the preceding day, a progressive amelioration was obtained, until the tenth sitting, and a complete cure was obtained. Thus the surgical operation was avoided, which would otherwise have been necessary, because the patient could not longer endure the pain of the sickness.

Peritonitis.—Two cases of peritonitis were treated with the condensed chemical light, with complete recovery of both.

Case I.—M. N., 26 years old, multipara, of good condition. For 6 months she had suffered with acute spasmodic pain in the abdomen, with frequent vomiting, hiccough, and vesical spasm.

Clinical Report.—There is a marked meteorism, with lancinating pain in the whole abdomen. It is impossible to make the least palpation on account of the painful spasm which it causes; the patient is unable to bear a light covering. Vomiting is frequent, micturition is spasmodic with the emission of clear normal urine. The pulse is small and quick, the respirations short, with frequent hiccough. All these symptoms are accentuated in the early morning hours, with convulsive twistings of the patient.

The æsthesiometer reveals a zone of hyperæsthesia in the left side.

Treatment.—Narcotics, emollients, warm baths, and all those things which are indicated for entero-peritonitis are of no value.

An application of chemical condensed light was made to the whole abdominal region for an hour. It produced a copious sweating with alleviation of the spasmodic symptoms. The pain in the early morning hours returned with its usual crisis, but with symptoms of less severity. She is able to bear slight manual pressure upon the abdomen without inconvenience. The phototherapy was repeated like that of the preceding day, with an amelioration of the general and local condition.

After two other exposures to the action of the chemical condensed light, she obtained a complete cure.

Five years have gone by without return.

Case II.—In a case of orrhymenitis (peritonitis) in a young woman aged 18, multipara, there was an exudative peritonitis with fever and gastro-intestinal disturbance. After a month a cough came on with dyspnœa, thoracic pains and hæmoptysis.

Clinical Report.—The illness was of 40 days' duration. She presented a pleuritic effusion in the right side. The liquid occupied two-thirds of the thoracic cavity. The semilunar space of Traube had disappeared, the pericardium and the abdominal cavity showed a separate effusion. The distention was very great, as shown in the photographic illustration, and the countenance bore the expression of pain and distress. The patient was anæmic, badly nourished, and had febrile disturbances. Intense lancinating pains, retrosternal, interscapular and abdominal were experienced. There was cyanosis, an angina, hiccough, vomiting and disordered cardiac functions.

The concentrated light was applied by Sciascia on every alternate day for one hour upon the thoracic-abdominal region. Fifteen exposures were made in all. The first treatment was followed by copious sudation, a sense of well-being, and alleviation of pain. The patient made a complete recovery.

Sciascia also reports one case, each of abdominal typhoid, gastric ulcer, arthritis blenorrhagia, and puerperal metritis, in all of which good results were obtained from the application of the condensed solar energy to the region of the lesion. A series of psychical conditions are also reported.

CHAPTER XII.

The Concentrated Energy of the Electric Arc Spectra, Carbon, Carbon and Iron, Iron. Mechanisms, Methods of Use and Therapeutic Indications. Finsen. Lupus Vulgaris, Lupus Erythematosus, Sycosis, Eczema, Tubercular Ulcers, Tubercular Glands, Neuritis, Neuralgias.

The Concentrated Energy of the Electric Arc Light in Skin Diseases.

The most important use of the concentrated chemical frequencies of light in skin diseases, in a certain sense, is in the treatment of lupus vulgaris. In the last report of his Light Institute at Copenhagen, Finsen[1] gives a résumé of 800 cases treated. In these 800 cases there was improvement in 90%, cure in 70%, reappearance in 20%, the latter being generally cases where the mucous membrane was involved.

The following table gives a detailed analysis of the 800 cases:

I. Apparently cured	407	122 .... 2–6 years	.... 51%
		285 .... 2 "	
II. Nearly cured....	193	....	24%
III. Marked improvement..........	89	24 .... partly	.... 11%
		65 .... marked	
IV. Not sufficiently treated........	40	14 .... not permanently	Improved 5%
		12 .. some improvement	
		14 ...... negative result	
III. Dismissed.......	71	33—died	
		13—sickness	
		25—did not return for treatment	

[1]Mitteilungen aus Finsen's Mediciniske Lysinstitut in Kopenhagen, 1904.

Finsen is of the opinion that not more than 2% of tubercular lupus cases can be regarded as incurable. And Bie has said that a failure of a case to respond to the action of light energy is an indication of a wrong diagnosis.

As the arc light mechanisms in use for therapeutic applications to localized areas are arranged (1) to concentrate all the energy of the arc by means of reflecting mirrors on the area to be treated, and (2) not only to concentrate but to condense the energy of the arc by means of condensing or focal lenses, as in the Finsen and Finsen-Reyn apparatus, the author has chosen to consider both methods under the single head of the concentrated energy of the electric arc, for such it is in both instances, but in the latter condensed as well.

In the text, therefore, wherever the means to the end is referred to as the concentrated energy of the arc, there is to be understood the full energy of the arc concentrated, by means of suitable mirrors, to a beam of lesser or greater diameter, according to the superficial area of the part to be treated, but without focal lenses; on the other hand by the concentrated and condensed energy of the arc it is to be understood that the energy of the arc is used at its focal spot, and through focusing or condensing lenses of quartz, as per the method of Finsen.

Of the apparatus described in the following pages, the Finsen, Finsen-Reyn, and the author's arrangement of the marine searchlight, with a water-cooled chamber, formed by means of two focal lenses of quartz, are the only mechanisms by which the energy of the arc is not only concentrated, but condensed as well. The marine searchlight as ordinarily used, the Victor or London Hospital lamp, the iron electrode lamp, and the apparatus of Bellini are all arranged for concentrating the light, but not for condensing, i.e., with focal lenses.

The essentials for a light mechanism for the treatment of lupus vulgaris and other skin lesions, as per the method

of Finsen, or for the treatment of other conditions to be subsequently considered, are:

(1) A sufficient intensity of electric current which produces the luminous output.

(2) An effective luminous output on the skin of the patient: That is a beam of light rich in a complex of the energy of all the frequencies from the blue on up to the ultra-violet, which is at once both bactericidal and capable of exciting tissue reaction. By this complex of wave energy a deeply penetrating effect is secured, as well as the superficial action upon the skin, due to the absorption of the shorter wave lengths or ultra-violet.

(3) The losses of effective energy between the arc and the skin of the patient: This is by reason of the position of the arc and the relation of the patient to it, for the nearer the source of light the greater the energy. This is according to fundamental physical law, i.e., that the intensity of light varies inversely with the square of the distance, but it is a law which holds good only for non-concentrated light.

(4) The influence of the media traversed; that is, losses by reflection or absorption: All media, air, water, glass, even superimposed quartz lenses weaken the force of the energy from the arc. Mirrors even used to reflect the light are a source of loss, but act better than the small lenses of quartz. Silver mirrors, for example, reflect only 92% of the visible spectrum, while an alloy (41% Cu + 26% Ni + 24% Sn + 8% Fe + 1% Sb) known as the Brandes-Schümann,[1] reflects only 50%, but reflects ultra-violet more than other metals.

Mirrors of the Brandes-Schümann alloy take a very good polish, and resist the action of the air. Steel might also serve as a reflector.

Victor Schümann, to whose research is due the measurement of the shortest wave length yet recorded, is authority for the statement that metal mirrors of magnalia, an alloy

[1]Quoted by Freund from Physik Zeitschr., 1900, Vol. II, p. 176.

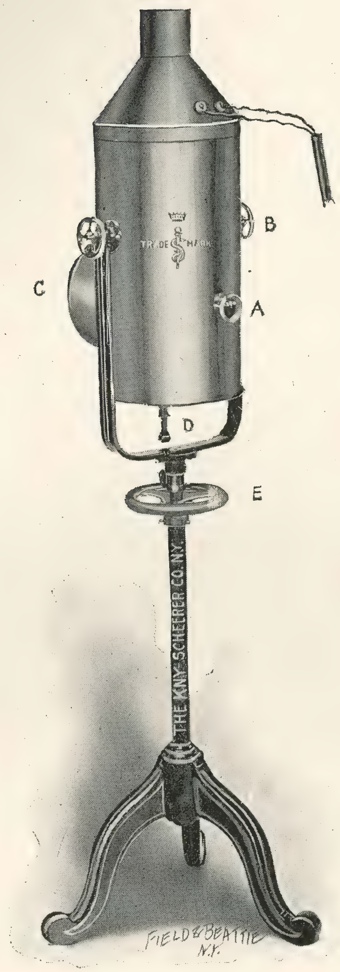

Fig. 54.—Therapeutic Arc Lamp of 25 to 40 ampères, direct current; requires no water cooling for shell; is very useful in skin diseases and other local conditions.

of aluminum and magnesium, reflect not only the visible spectrum, but the ultra-violet very satisfactorily.

(5) Compression to render anæmic the tissues to which the application is to be made must be considered in order that the effective energy need not be absorbed by the skin to too great an extent.

(6) A comfortable position of the patient in relation to the light mechanism is also a requisite, as well as a means of depriving the light energy of its heating effects.

The experiments of Bernard, Morgan, Freund, Bie, Leredde and Pautrier would indicate that the shorter and more frequent the wave lengths the more useful they are: (1) in bactericidal activity, (2) in exciting tissue reaction. On the other hand, the longer they are the deeper they penetrate. From this the conclusion is reached that the frequencies between the two extremes are the most useful, that is from the blue into the ultra-violet.

Nature of Electrode Contacts.—When the electrodes supplied to an arc lamp are either iron, or, in the author's judgment, iron incorporated into the mass of the carbons, there is a very marked contrast between the color, and that from carbon electrodes alone. The light from carbons alone is of a dazzling whiteness, while that from iron and carbon shades from an intense dead or blue white to a bright violet color. Iron is very rich in the violet and ultra-violet frequencies, but exceedingly poor in the longer and slower frequencies, and, therefore, of limited power of penetration. While these intense chemical activities are of the greatest value, they need to be associated with the longer wave length of that part of the spectrum known as blue, in order to secure the best results.

For several years the author has used lamps of from 25 to 80 ampères with the best carbons obtainable, carbons through which a core of wire in the shape of an iron rod has run axially, or electrodes in which iron has been incorporated in the mass of the carbon. The latter are the better, and they can be obtained in this country from the manu-

facturers of arc lamps, or directly from the carbon-electrode manufacturers or importer. As the spectrum of carbon is slightly deficient in blue, as compared with solar light, the addition of iron is an advantage. By this combination of iron and carbon a spectrum very rich in the visible chemical frequencies, or blue, indigo and violet, as well as the invisible or ultra-violet frequencies, is combined with that of iron. In this connection the following is of interest:

Arc Light Electrodes.—Recently Vogel[1] states that experiments for the purpose of ascertaining the chemical relations which take place in an arc light between carbon electrodes containing ingredients intended to increase the light, have determined that the acid fumes of metallic salts rather decrease it than otherwise, being bad conductors of electricity, and also poor dispensers of light. On the other hand, the conducting and light-emitting powers of alkaline, alkaline earth and rare earth metal fumes are very good, and the results of value, when the loss of energy caused by the vaporization of the substances is compensated for by the increased concentration of the gases, and the temperature of the arc raised by an internal chemical decomposition initiated by the introduction of free ozone. The essentially novel and characteristic feature of Vogel's invention, which produces the increased emission of light, is the separation, by means of a carbon partition, of the materials yielding oxygen from the light-emitting substances, and the central arrangement of these passages, in order that the oxygen may only reach the vapor of the illuminating substances after being ozonized.

However, if one recalls the photosphere of the sun, formed as it is of a "colossal storm of rain and hail, of liquid and semi-solid diamond," that is chemically pure carbon, and that life is sustained by the radiance from the photosphere, the conclusion is forced that, after all, there is nothing better for phototherapeutic work than electrodes of the purest carbon obtainable.

[1]The Electro-Chemist and Metallurgist, April, 1904.

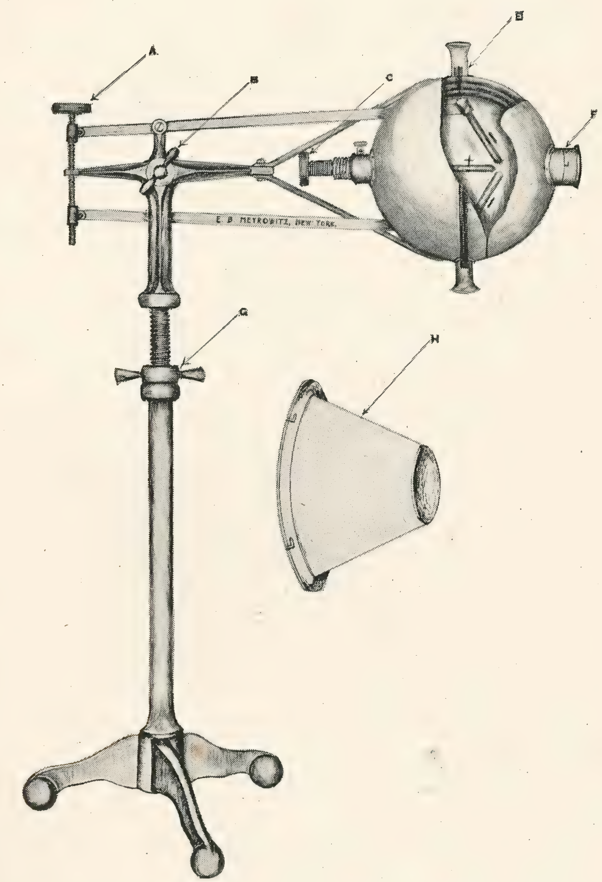

Fig. 55.—The Cleaves Arc Lamp—for alternating or direct current, local or general applications; requires no water for cooling shell; projects the light of the arc directly upon exposed area; ampères 40 to 70.

The Type of Mechanism Selected is Governed by the Nature of the Work to be Done, i.e., the Pathology.--The first point, then, to be considered is the arrangement of mechanisms to be used for the purpose of concentrating the chemical frequencies of light, or in the method introduced and practiced by Finsen, of not only concentrating but condensing the light frequencies as well. If the condition to be treated is one involving extensive and well-organized infiltrations, as lupus vulgaris, for example, then an arrangement of mechanisms utilizing to the full the chemical frequencies of a source of light, from 25 ampères upwards, should be selected, for here a great quantity of light is needed. They should be used preferably with focal lenses, for the maximum of energy is at the focal spot.

If, on the other hand, the lesion is more superficial and less well organized, a source of light of less ampèrage is sufficient, the small iron electrode arc lamps, for example, while in many recent and still more superficial conditions, a source of light giving ultra-violet frequencies only, as from the spark condenser lamp, is of value. This latter fact is due, as has been pointed out, to the fact that ultra-violet frequencies have very little penetrant power, and are, therefore, inadequate, where a profoundly penetrating effect is desired. With these latter mechanisms the use of focal lenses is not imperative.

To Finsen the profession is indebted not only for the careful preliminary study and investigation showing conclusively the rôle of these frequencies in skin diseases, but also for the application to therapeutics of a scientifically constructed apparatus for the use of concentrated electric-arc light energy. Similar apparatus had long been used in physical and medical laboratories. In the Vienna Institute of Experimental Pathology, apparatus constructed exactly the same had been used for many years to project light by Professor Paltauf, and formerly by Professor Striker.[1]

[1]Freund.

In his experiment as to the action of light, Widmark,[1] in 1889, made use of the same kind of apparatus. All of which is illustrative of the fact that the means to the attainment of a definite end in all matters of scientific development lie at our door awaiting the interpretation of and application by the intuitive intelligence. Such is the order of genius possessed by Finsen, and having proved by his experimental work the action of light he was at once able to

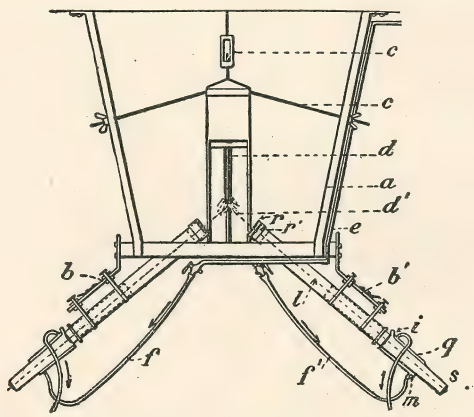

Fig. 16.—*a*, support of the apparatus; *b*, support of the tubes; *c*, support of the lamp; *d*, positive carbon; *d'*, negative carbon; *e*, water feed; *f*, *f'*, rubber tube for water inflow; *i*, rubber tube for water outflow; *m*, entrance of water into cooling chamber; *l*, tube with lenses; *g*, metal cylinder for the circulation of water; *r*, *r'*, lenses to render the rays parallel; *s*, lenses to render the rays convergent.

supply the needed apparatus for the utilization of the intense chemical frequencies of light energy from an electric arc. His first therapeutic applications were made with concentrated sunlight, but it was not possible to obtain in that way sufficient energy, and, moreover, in northern latitudes, as that of Denmark, the sun was not always in evidence.

Finsen's Concentrator.—Finsen's apparatus consists of a telescopic tube, by means of which the divergent rays of an electric arc are collected into parallel rays. These parallel rays are then collected into a cone, the apex of which is

[1]Quoted by Freund.

allowed to fall upon the part of the skin to be treated. Fig. 16 gives a diagrammatic cut of Finsen tube. This tube, which is the connecting apparatus between the source of light energy and the patient, consists of 2 metal cylinders telescoped one into the other, each one of which contains

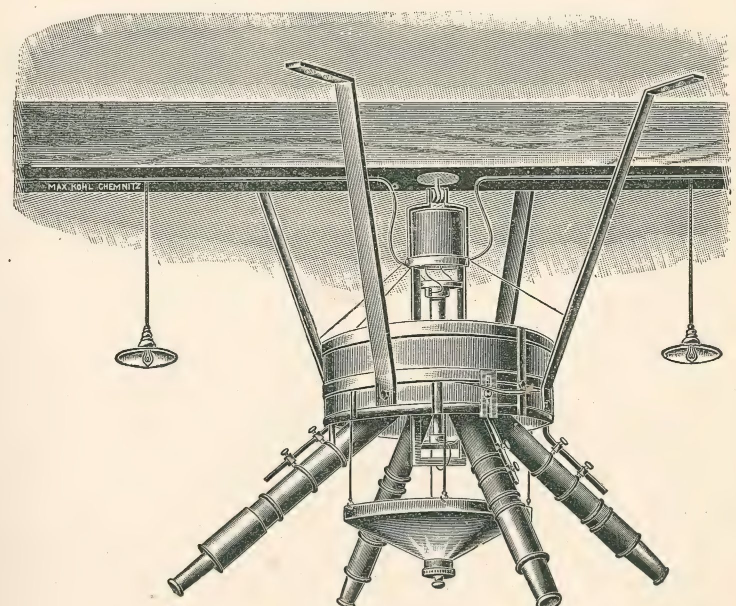

Fig. 17.—Finsen Apparatus.[1]

two plano-convex lenses of quartz. These two parts of the apparatus may be separated by a rack and pinion movement. The various lenses are so proportioned as to size that 1 and 2 have together a focal distance of 12 cm., while 3 and 4 have a focal distance of 10 cm.

By the lenses 1 and 2 nearest to the source of light, the divergent rays of the electric arc are gathered into a bundle of parallel rays; then by the action of the lenses at 3 and 4 these parallel rays converge on the surface to be treated. This is about 10 cm. outside of the lens marked 4. In the

[1]From Freund, Radiotherapy and Philotherapy.

original tube the water chamber was fixed between lenses 3 and 4, and kept filled with distilled water for the purpose of absorbing the thermal frequencies. This part of the cylinder is in turn surrounded by an additional chamber through which, by an afferent and an efferent system of rubber tubes, connected with the source of water supply, cold water is kept circulating through the mantle surrounding the water chamber at the distal end of the tube.[1] Otherwise the water becomes boiling hot.

Alternating Versus Continuous-Current Arcs for Concentrating and Condensing Light Energy.—For his source of light energy Finsen uses a continuous-current electric arc of 80 ampères. He estimates its light intensity at 40,000 candle-power. An alternating-current electric arc is not suitable where concentration of the light energy is desired, for, as has been pointed out under the physics of the electric arc, there is no longer a continuous flame, but the arc is alternately lighted and extinguished at every reversal of the current. The light is, therefore, unsteady and unsuitable for concentration.

Resistances to Cut-Down Voltage.—The E. M. F., 110 volts, of the continuous-current as supplied from the street mains, is greater than is required for the operation of an electric arc. This is true whether an arc of 80 ampères, or arcs of greater or less ampèrage are used. In the author's use of an 80-ampère arc to operate a Finsen tube a suitable resistance or rheostat capable of using up the extra voltage is used. This is also done with 25 and 50-ampère arcs.

The Necessity for Heavy Wiring to Carry Large Currents.—The wiring for arc lamps must be heavier, i.e., capable of carrying greater ampèrage than for the ordinary electric lighting of dwellings. This varies according to the current consumed by the arc. For an 80-ampère arc a heavy, well-insulated wire is required.

[1]Vlademar Bie, The Phila. Med. Journal, Oct. 4, 1899.

Not Only Light Requisite but a Quantity of Light.—In the selection of an electric arc lamp the reader will recall that it is not only light that is needed, but a *quantity* of light, and that the amount of light is not increased per unit of area with the current, but the size of the crater is increased, which increases the amount of light emitted. This is true with given carbons at a given distance apart. With both ampèrage and larger carbons, there is still a further increase in the size of the crater, and consequently in the unit of area, which means still more light, and especially more of the valuable short and high frequencies so active chemically.

The Position of the Finsen Apparatus in Relation to the Arc.—Finsen's 80-ampère arc is suspended from the ceiling (or it may be adjusted upon a very high table if desired, either iron or iron-covered). In the Finsen Light Institute the arc is suspended from the ceiling, as is shown in Fig. 17. There are arranged around a single lamp, four of the concentrators or tubes described, each in turn being secured to an iron in order to utilize its energy for the simultaneous treatment of four patients. This ring in turn is fixed to the ceiling by four iron supports. The spaces between the single concentrators are filled with asbestos plates, in order that the operators and patients may not be exposed to the action of strong light.

The apparatus is movable up and down as is shown by the pendant drop attached to an arrangement of pulleys. The concentrators are adjusted at an angle of about 45 degrees in relation to the arc, because it is at this point that the greatest energy of the arc is to be obtained. In this way the points of the carbons are exactly in the focus of the proximal lenses of all four of the concentrators.

Water Cooled Compressing Lens.—As the light, however, from this doubly cooled apparatus, i.e., water chamber and superimposed mantle or jacket, still produced too great heating effects, Finsen devised a hollow compressor consisting of a plate of quartz and of a plano-convex lens of

quartz both framed in a conical brass ring, carrying two small tubes and four arms. To each arm elastic bands are secured in order to adjust the compressor with equable pressure to the part to be treated, while the two small tubes connected with the interior chamber of the compressor are again in turn connected to a source of water supply by a system of efferent and afferent tubing providing for the constant circulation of cold water. In this way the remaining heat is done away with, while at the same time from the firm and equable

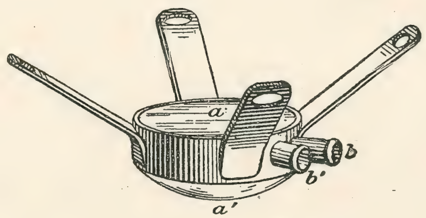

Fig. 18.—Compressor; *a, a'*, lenses of quartz; *b*, tube for the inflow of water; *b'*, tube for the outflow of water.

pressure upon the part to be treated the blood is driven out, rendering it anæmic, in which condition absorption of the chemical frequencies is assured. If elastic bands do not suffice to maintain it in position a suitable arrangement of bandages may suffice or it may be held by the operator's hand.

The Necessity for Lenses or Plates of Quartz.—In his first apparatus Finsen used glass lenses, but later on replaced them with lenses of quartz because of the physical fact that ultra-violet frequencies are absorbed by glass. The physical reason for the transparency of the one and the opacity of the other the reader will recall is given in Chapter II., the Physics of Light Energy.

It is only feasible to get quartz lenses of small diameter. The larger ones are not only difficult to get but very expensive. This is due not to the expensiveness of uncut quartz but the difficulty encountered in accurate and even cutting of lenses or plates, but especially the former. Quartz is very

prone to break along its lines of crystallization and the cutter never knows when this accident may befall. The author has been informed that as much as a ton of quartz was used before a perfect single focal lens of quartz 2 inches in diameter was obtained. Moreover, it is impossible to utilize to the best advantage the energies of the electric arc with small lenses. This fact, in connection with the powerful arc required for the successful operation of the Finsen tube, the distance of the distal end from the source of light energy, the expense of current consumed and the long sittings required, at once led different investigators and manufacturers to construct apparatus which not only would not have these disadvantages but would have greater merit. With a Finsen tube and an 80-ampère arc the author found it necessary to make exposures of from one to two hours in duration. The tax upon the patient's endurance was very great as well as upon that of the operator, while the expense of current was enormous. These are factors which do not necessarily enter into Finsen's work, as it is supported by the Government. In a private office, however, it is another matter. But while ampèrage is desirable, it is not the only factor, as has been pointed out under the physics of the electric arc. Suffice it to say that with the Finsen tube a considerable part of the effective energy is lost in passing through the water-containing cylinder, and the unavoidable use of so many lenses weakens the force of the energy which is allowed to pass.

The Lortet and Genoud Apparatus.—One of the earliest and, at the same time, the best practical substitute which appeared was the Lortet and Genoud lamp, manufactured at Lyons, France. The following description of this apparatus was written by the author in 1901.[1]

The continuous current electric arc is produced between two carbons forming an angle sufficient to allow the crater of the positive carbon to project the greater part of the light in

[1]The Electric Arc; Its Physics, Physiological Action, Therapeutics and Arrangement of Mechanisms. Margaret A. Cleaves, M.D., The Journal of Physical Therapeutics, July 10, 1901.

a cone, whose axis passes through the centre of an orifice. The orifice is situated in the centre of a sort of vertical basis with a double bottom, the walls of which, about a quarter of an inch apart, leave a space for the constant circulation of water. This water prevents the heating of the basin, which acts merely as a screen, and is provided with an orifice through which the light passes. A system of jointed arms and screws permits of the regulation of the arc, which may be brought within variable distances of from one-half to three-quarters of an inch from the orifice. The carbons are concealed by the flanges of the spring, and a small mirror prevents any projection of light to the rear. In front of the orifice there is fixed a sort of hollow shutter, limited upon its two faces by discs of rock crystal, in the interior of which circulates a current of water. The electric arc may be brought to within $2\frac{1}{2}$ inches of the shutter without the latter becoming heated. The apparatus is mounted upon a rod movable in all directions, so that the manipulation of it is rendered very easy.

With this apparatus it is possible to utilize the full energy of the high frequency waves of the arc, for by the absence of condensing lenses, and the nearness of approach to the patient little, if any, opportunity is offered for their dispersion.

By the Position of the Carbons the Light of the Arc, or Blue Mist and Reflection from the Crater is Secured.—The position of the carbons at an angle of 45 degrees is also a factor for the light of the arc proper or blue mist is fully exposed to the inner quartz plate, the crater of the positive electrode serving at the same time as a reflector. This is most important, for, as has been noted, the chemical rays have short wave lengths and high frequencies, and can agitate little things in their path, such as molecules, and as this agitation is what is assumed to effect chemical change, it is most important that every opportunity of dispersion of activity in transit from the source to the patient should be minimized. With this apparatus, Lortet and Genoud find that

Fig. 19.—Victor Lamp.

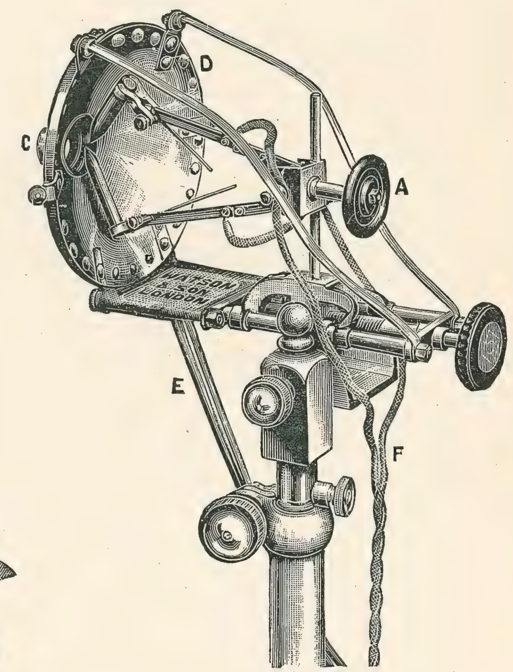

Fig. 20.—Lortet et Genoud Lamp.

an exposure of from 15 to 20 minutes suffices against an hour and a quarter with the Finsen tube. This is due to the securing of a residual beam of much greater total energy than is obtained from a tube with condensing lenses of quartz. This residual beam, to be properly effective, must possess the greatest possible number of high frequency waves of considerable amplitude, a beam not only of high intrinsic energy, but greater total energy. As the amount of work accomplished always depends upon the amount of energy expended, it follows that a shorter exposure should give equally, if not better results. But one factor minimizes this effect, and that is the absence of condensing or focal lenses of quartz, as will be shown in a comparative estimate of different light mechanisms. They are, however, supplied by the manufacturers. The effect desired in lupus, for example, must be produced by the maximum of chemical activity, which means not only a maximum intensity of the very high frequencies, but a complex of all the frequencies, waves of greater length and amplitude as well as those of shorter length and less amplitude. In less resistant pathological conditions, so to speak, as in the stimulation of a simple ulcerating surface, a chemical effect produced by a less intensity would be sufficient.

The apparatus of Lortet and Genoud is commendable also from the practical point of expense. It can be constructed at one-third the cost of a Finsen tube, and as the length of exposure is reduced by reason of the total energy, the cost of current is proportionately reduced, a point which cannot fail to be of much moment in influencing the use of light by the profession in localized skin affections. The same arrangement of arc-light mechanisms was adopted by the London Hospital as that of Lortet and Genoud and it is now very widely known as the London Hospital Lamp. More recently the same mechanism has been put upon the market in this country, and is known as the Victor-Finsen lamp, Fig. 19. The manufacturers have been careful not to depart from many of its excellent features but have

neglected to supply a screen for catching the products of combustion and also for the protection of the operator's eyes. It is well constructed and the author has found it satisfactory where the concentrated energy of an electric arc is desired in the more deeply seated pathologic conditions and also well-organized skin conditions. It takes 17 ampères of current and is provided with a suitable resistance which cuts the E. M. F. down to 45 volts. The metal reflector back of the arc is larger than in the original Lortet and Genoud lamps. The manufacturers[1] will in future provide their apparatus with the screen for the protection of the eyes and, also, a second one for the purpose of collecting the particles of burning carbon. The latter is shown in a cut of the Lortet-Genoud Lamp. See Fig. 20. This lamp is provided with especially prepared carbons, in which iron is incorporated into the mass, thereby increasing the intensity of the chemical energy of the high and short frequencies.

Comparison of Finsen's Apparatus and that of Lortet and Genoud.—Finsen's apparatus gives by reason of the high-ampèrage arc used not only the short and high frequencies of intense chemical activity, but also the frequencies of long wave lengths, great amplitude and penetrability, a complex which is essential to secure the best results. With the Lortet and Genoud or Victor, the long wave lengths of great amplitude are not present in such abundance because of the lesser ampèrage and smaller carbons.

The Finsen-Reyn Apparatus.—The Finsen-Reyn apparatus, arranged for the treatment of a single patient, is a 20-ampère, 55-volt carbon arc. The carbons are arranged perpendicularly as in the Finsen apparatus. It differs from the original Finsen, not only by its lesser ampèrage, but by having the water for cooling purposes placed at the proximal end of the tube instead of the distal. Between the arc and the first lens, there is placed a plate of quartz instead of a focal lens as in the Finsen apparatus. The space between these two forms a water cooling chamber, the function

[1] Personal communication.

of which is to prevent undue heating of the first lens with the possibility of injury to the lens. This approach permits the uniting the divergent rays into a more powerful sheaf of parallel rays nearer the patient, i.e., at the first focal lens. In this way an arc of 20 ampères at 55 volts is almost equal to that of Finsen (in the test) 70 ampères and 50 volts. The advantage of the latter, however, lies in the larger carbons used with a higher ampèrage, for by them the unit of area of light is greater and hence 4 concentrators can be used with the one source of energy and 4 patients treated at once. In this country the best lupus or skin lamp is unquestionably the Lortet and Genoud or Victor lamp. If supplied with condensing lenses instead of plates it would be more effective.

The Apparatus of Bellini.—Bellini,[1] in describing his own apparatus, states that when subjected to the same test as the others, the result was the same as with Finsen's. It was used with a 20-ampère, 55-volt arc. He uses a dioptric apparatus in the form of a truncated cone, in the centre of the major base of which is placed by means of a screw a ring holding 2 plano-convex lenses of quartz, with the convexities joined end to end. In the middle of the minor or smaller end of the truncated cone a plate of quartz is placed which serves as a compressor. This truncated cone is filled with distilled water still further cooled by a coil of potable water. The ring at the major base is almost completely immersed in the distilled water. It is cooled, and consequently the temperature of the first lens facing the arc, while to that is communicated the coolness of the convexity of the second lens, which has a plane face in contact with the distilled water. In this way the arc can be used at a distance of 3 cm. without danger of cracking or injuring the lens by heat. By the 2 plano-convex lenses of quartz with convexities facing each other, the use of a disc of quartz to gather up the parallel rays is obviated. Bellini shows by algebraic formula

[1]A visit to the Phototherapeutic Institute, Finsen, of Copenhagen, by Dr. Angelo Bellini, of Milan, Revue Internationale d'Électrothérapie et Radiothérapie, Nov., 1903.

that the first lens of the Finsen-Reyn is not correctly placed, but that the anterior disc of quartz ought to be placed at nearly 4 cm. from the arc, as the quartz disc and the water take about 3 cm., and the correct focal distance his equation shows to be 7 cm.

Marine Searchlight Mechanisms.—Marine searchlight mechanisms of from 20 to 80 ampères, provided with large reflecting mirrors of the Mangin type, projecting the beam upon the patient's body at a distance of from 7 to 15 feet, according to the light intensity, are used to a considerable extent in the United States. The author has had in use for the past 4 or 5 years such a 25-ampère marine searchlight capable when adjusted on a short focus, of picking up and observing the manœuvres of a vessel at a distance of one and one-fourth miles. The term focus in this instance refers to the position of the crater of the arc in relation to the mirror.

Fig. 21 shows a cut of the apparatus with the glass door which closes the drum, when used as a searchlight, open. The arc which is enclosed in this drum of sheet iron, mounted in brass or nickel, has a 12-inch Mangin mirror projector, concavo-convex, at the back of it, by means of which a much more powerful light is secured than would otherwise be obtained. The lamp is of the automatic focusing type. The door is left open during all therapeutic applications in order that the short and high frequencies or most intense chemical energy need not be lost by filtering through the glass.

For general application where large square-inch surfaces are involved, as the chest in pulmonary tuberculosis, for example, the arc should be adjusted on short focus, i.e., with the crater of the arc $5\frac{1}{2}$ inches from the concavity of the mirror. The beam of parallel rays, at from 10 to 15 feet, is 12 inches in diameter, and can be projected at will on any part of the body. The light mechanism is secured to a cast-iron base, and by means of a swivel joint can be rotated in any direction required. By means of another swivel joint the mechanism can be raised or lowered at will, so that the

beam may be directed to any level of the body indicated by the pathological conditions.[1] This mechanism is to be had mounted on a sufficiently high standard of its own. See Fig. 22, or a lower one, as is shown in Fig. 21. In the latter instance it is necessary to place it upon a low table or stool. Application may be from 15 to 20, 30, 45, or even 60 minutes in length. It is the exception that the longer exposure is necessary. In an acute bronchial cold, with dyspnœa, constriction, dry and painful cough, a 20-minute exposure established free respiration, markedly diminished pain and general sense of relief, which persisted, and was promptly followed by loosened cough and free expectoration. Such an application causes considerable redness of the skin, as nothing is used to absorb the heat, and all the frequencies are active.

Screens of Blue Glass.—To eliminate the long and low frequency rays, a screen of blue glass, shown in Fig. 21, can be placed between the patient and the light. In this way the thermal effect is minimized to such an extent that a prolonged application can be borne for any period of time desired.

The use of the screen, however, cuts off the ultra-violet frequencies, thereby diminishing the intensity of the chemical action. Still, therapeutic results seem to warrant the conclusion that the diminution is not sufficient to interfere with results in general conditions.

The writer prefers the entire radiant energy of the arc, and never interposes the screen save where there is undue sensitiveness to the sensation of heat. Even in very nervous patients the action, as a rule, of an expenditure of this radiant energy is extremely quieting and beneficial.

Funnel-Shaped Adjustment of Marine Searchlight, for Purposes of Localization.—The author found, after an experience of several years with a Finsen tube, operated in connection with an 80-ampère arc, that it was too expensive

[1]Where an application to the entire body is desired the writer prefers the cabinet heretofore described. See Chap. IX.

Fig. 21.—Marine Searchlight, with Blue Glass Screen.

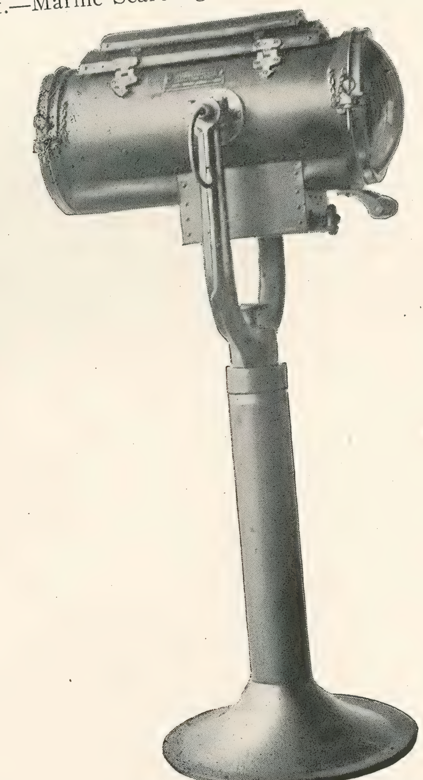

Fig. 22.—Marine Searchlight on High Stand.

to operate and required too much time for a busy office hour, not devoted especially to skin conditions. It was, therefore, laid aside, and as a result of a good deal of experimental work with various forms of electric arc light apparatus, the author with the assistance of the manufacturer of marine searchlights, succeeded in arranging the marine searchlight which was in use for general applications in a very simple and inexpensive manner for skin localization. While the highest chemical activity of the energy of the arc cannot be obtained from carbons horizontally placed, this simple arrangement has given very great satisfaction.

By changing the focus of the lamp from a short to a long one, i.e., from $5\frac{1}{2}$ to 6 or $6\frac{1}{2}$ inches, and by the funnel-shaped lid, made of black Russia iron, or copper, preferably blackened on its inner surface, the greatest energy of the beam is secured at a distance just outside the opening of the funnel, or not to exceed 12 inches from the distal end, according to the adjustment of the carbons as they are diminished in length by use. See Fig. 23. This is the focal spot. The arrangement of the focus brings the beam down to a diameter of one and one-half inches, and the funnel of black iron absorbs the heat rays as they impinge upon its sides, while the residual beam of the greatest activity of the arc possible with a horizontal adjustment of the carbons is projected from the opening upon or into the part to be treated. To such an extent is the heat absorbed that the beam can be projected upon the area of diseased tissue just outside the end of the funnel save for the intervening compression of quartz, or at will at a distance or from 1 to 12 inches, without the intervention of any filtering or cooling device. In the treatment of unbroken skin conditions, lupus vulgaris and erythematosus, and in the nodules of recurrent carcinomas, a small block of ice may be secured to the skin surface if desired. This will render the part anæmic, both by pressure and by cold, and will at the same time serve as a heat filter without interfering with the effective energy of the arc. In a chronic eczema of the lobes of the ears, a 20-

minute exposure through a compressing lens of quartz at a distance of 6 inches from the distal end of the funnel from a carbon arc, was readily borne. When iron and carbon is used, the heat is minimized to such an extent that in both mucous membranes and skin contacts there is no sensation of heat at all. The resulting beam, however, is not so deeply penetrative as the pure carbon arc alone. There is no intervention of lenses for cooling or other purposes, and the rays that proceed in a straight line are reflected without passing through the Mangin mirror at the back of the drum, while only those that proceed at an angle pass through the mirror before they are reflected. As the rays passing in straight lines represent the greatest energy it follows that the mirror interferes but little with the value of the light activities.

With this special adjustment of the marine searchlight it is then possible to use the beam of light for actual skin contact, with the intervention only of a compressor of quartz, or a slab of pure rock salt when the positive or iron-cored carbon is fresh.

The Heat When the Arc is Freshly Trimmed Due to the Resistance of New Carbons.—From the first burning of a fresh negative carbon, however, even when the positive is iron-cored, there is given off an intense heat, but as soon as the resistance of the new carbon is overcome there is a steady arc, and the beam of light passing through the opening of the funnel-shaped attachment is so far devoid of heat as to permit of its use as stated, in skin contact, or in mucous membrane contact—mouth, nose and vagina as well. When both positive and negative contacts are iron-cored, the resulting beam of light is even richer in intense chemical energy than the previous arrangement, and burns from the first at a lower temperature, and can, therefore, be used without waiting to overcome the resistance due to the first burning of the carbons. With this arc light mechanism the author has a second funnel of copper to which a brass water-containing cylinder, enclosed at its two ends by means of focal lenses of

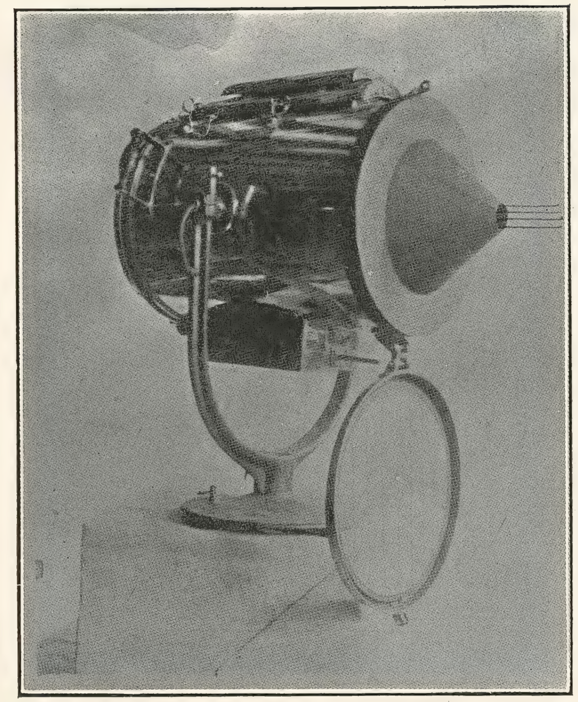

Fig. 23.—Marine Searchlight, with Funnel-shaped Attachment.

readily the intense heat of the arc. This is also constructed for use on either continuous or alternating-current mains. It is known as the apparatus of Dr. Schall.

Dr. G. Kaiser, whose experiments are quoted in Chapter XIV., also uses a powerful marine searchlight, filtering the light energy through a blue glass screen, as is done in the apparatus used by the author.

Actinolyte.—An arrangement of a focusing arc carrying from 30 to 50 ampères of current, with 2 plano-convex lenses of glass, 8 inches in diameter, supplemented at will by a double convex glass lens of from 6 to 8 inches in diameter, is also in use and is known as the Actinolyte. With this arrangement the beam of from 6 to 10 inches in diameter is projected upon the part of the body in which a localization is desired; for example, the chest walls in tuberculosis pulmonalis. Here, however, all the precious ultra-violet frequencies are lost by reason of the plano-convex lenses of glass and mechanisms arranged in this way are not considered desirable at all. The beam from them is very hot despite the circulation of water. The apparatus is therefore not recommended as at present constructed.

Tests of Apparatus at the Finsen Light Institute.—Different forms of apparatus were tested at the Finsen Light Institute in an original way. A number of rabbits' ears superimposed, behind which was a piece of photographic paper, were submitted to the instrument in turn. The following results were obtained:

Number of Rabbits' Ears.	Apparatus of Finsen.	Apparatus of Finsen-Reyn.	Apparatus of Lortet-Genoud.	Apparatus of Bang.
	70 Amp. 50 Volts	20 Amp. 55 Volts	15 Amp. 50 Volts	8 Amp. 35 Volts
1	" 1 sec +	" 1 sec.+	" 1 sec.+	1 min. – 1¼ min.+
2	5 sec. – 6 sec.+	6 sec – 7 sec.+	20 sec. – 25 sec.+	5 min. – "+
3	20 sec. – 23 sec.+	20 sec. – 22 sec.+	4 min. – 5 min.+	" – "+
4	2 min. – 2½ min.+	2½ min. – "+	" – "+	" – "+

The + sign signifies the shortest time necessary for an action to be produced upon the photographic paper through the ears of the rabbits.

An analysis of this table shows that the light of the Finsen, Finsen-Reyn and Lortet-Genoud apparatus traversed the one ear in the same time. This illustrates that the value of these different ampèrages and arrangement of arc-light mechanisms is equal for the more refrangible rays which are absorbed by the first layers of the skin. The Bang lamp, an iron electrode lamp from which the water-cooled iron electrode lamp shown in this chapter is modelled, required very much longer. This means that iron electrode arc lamps rich in ultra-violet as they are, have very few of the penetrating blue-violet frequencies. From their use profound erythema and blistering of the skin results, but the action is superficial.

With two rabbits' ears superimposed, the superiority of the Finsen apparatus is clearly shown, the Finsen-Reyn being a close second, the Lortet-Genoud lagging behind, while the Bang lamp made no impression at all as it does not emit penetrant frequencies. With three rabbits' ears superimposed the Finsen-Reyn apparatus leads, the Finsen is second, the Lortet-Genoud requires 5 min. as against the 22 sec. of the Finsen-Reyn and 23 of the Finsen, while the Bang lamp is frankly unequal to the task. With four rabbits' ears superimposed, the Finsen apparatus clearly demonstrates its superiority over all the others. By reason of the ampèrage and the larger carbons required, there is a larger unit of area than with the arcs of lesser ampèrage and smaller carbons. This means a greater quantity of the penetrant frequencies and demonstrates most clearly the need of arcs of high ampèrage for deep-seated processes. It also shows the futility of attempting to treat them by means of iron electrode lamps.

Iron Electrode Lamps.—A great deal of experimentation on the part of those using light energy has been made in order to secure arcs giving the maximum of chemical activity. This has been based upon the idea that the ultraviolet are the frequencies most active therapeutically. Many different substances have been used for electrodes instead of carbon, for example, metals and substances not readily fusi-

ble, as lime, silicic acid, zircon, thorium and magnesium compounds.

Finsen tried filling the positive carbon, first hollowed out, with a mixture of graphite and calcined lime. As pure metals in the process of volatilization are apt to melt and drip, forming a bridge between the electrodes, which extinguishes the light, it was necessary to devise some means of cooling them. To this end Dr. Sophus Bang, Finsen's assistant, devised a water-cooled iron electrode lamp. A lamp modelled upon this is manufactured in this country. This difficulty is also met in an iron arc, modelled after one of French make, by permitting a free circulation of air about the arc, a description of which will be found upon a subsequent page.

Iron Electrode Lamp.—The lamp shown in Fig. 24 is modelled after the one devised by Dr. Sophus Bang, Finsen's assistant, and is a good representative of water-cooled iron electrode lamps. It is of value in the treatment of the more superficial skin conditions. It is easy to handle. The electrodes are kept cool by the constant circulation of water and the beam of white light is absolutely cold. It is provided with a simple quartz plate, which permits the passage of the ultra-violet frequencies and at the same time serves as a compressor. It is operated on the direct-current circuit of 110 volts and is provided with a suitable resistance.

In England there is a lamp much in use constructed on the same principle as the Bang lamp, known as the "Dermo."

It is good in the same class of cases as the iron electrode lamp mentioned above, but where very great penetration is desired, lamps of greater ampèrage, and with carbon electrodes are to be preferred. But the advantage is not one of metal only. It relates as well to the size of the electrodes. The iron electrode lamps are always small, and contacts likewise, the result is an arc of limited unit of area, and as the amount of light depends upon the unit of area, it follows that the emission of light is less than with carbon contacts, which, by reason of their size, give a larger unit of area. The iron

arc is also a light deficient in the maximum quantity of penetrant frequencies, blue, indigo and violet, although extremely rich in ultra-violet frequencies. Great care should be taken to keep the quartz plates or lenses of these iron electrode lamps absolutely free from dust or from dirt of any sort, as the perfect transmission of the ultra-violet frequen-

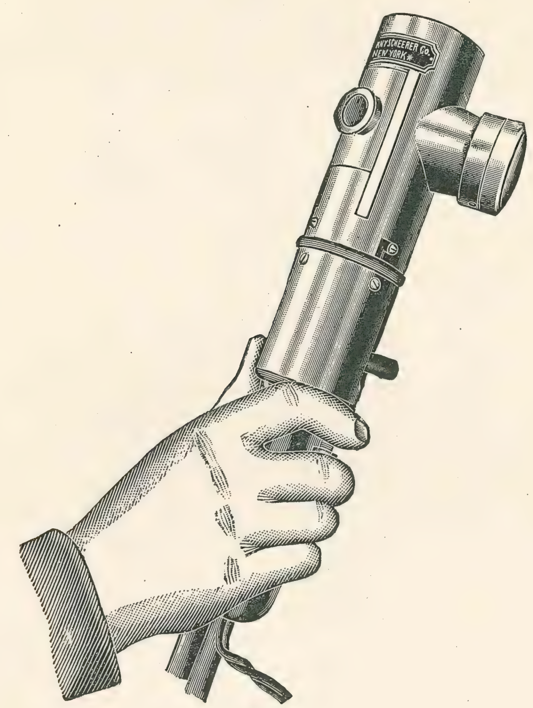

Fig. 24.

cies, the bearers of the precious chemical energy, is otherwise impossible.

Iron Volatilizes at a Lower Temperature than Carbon.—During the burning of the carbons the iron is volatilized at a lower temperature than the carbon, and from its vapor is supplied the extreme of the invisible chemical frequencies of light. By reason of the fact that it volatilizes at lower tem-

perature, the thermal frequencies are not so intense nor abundant as with carbons alone. It is well to have at command an assortment of contacts, pure carbon, and a composite contact in which the iron is thoroughly incorporated into the mass of carbon before it is subjected to the pressure of the moulding process.

When the iron is thus incorporated into the mass of carbon the entire unit of area of light is rich in the extreme chemical frequencies as well as in the longer and more penetrating frequencies. The beam of light thus produced is especially valuable for an application at a distance in the treatment of large areas, where a general or systemic effect is desired. For a localization these iron-cored carbons are equally satisfactory, because of the intense chemical activity in the centre of the crater where the iron core is volatilized. For great penetration, however, it must always be borne in mind that carbon arcs are to be preferred.

The Piffard Lamp.—Recently Piffard has modified a lamp of French[1] make. It has the general outward form shown in Fig. 25. This belongs to the same class as the iron arc of Sophus Bang. The electrodes are of iron and solid and by the free ventilation of air about the arc the circulation of water is dispensed with. One of the electrodes is fixed, to which the positive terminal of the source E. M. F. should be connected preferably; the other is movable and by means of an adjustable spring is maintained at a proper distance to form the arc. By a suitable resistance in series the lamp may be attached to any outlet with a commercial 110-volt direct-current circuit.

The fuse wire connected to the outlet on the wall should be capable of carrying at least 6 ampères. The conducting cords with the rheostat in series are furnished at one end with an attaching plug and at the other with sockets for connecting the lamp. The cord should be insulated with asbestos, and not with rubber or guttapercha. When the

[1]Archives d'Électricité Medical, March 15, 1902.

lamp is to be used it should first be connected with the cords, and the cords afterward connected with the desired part of the house service. The current should then be turned on at the socket. To produce the arc,—the push button on the handle is moved forward until the terminals are in contact, and then brought gently back to permit the arc to form.

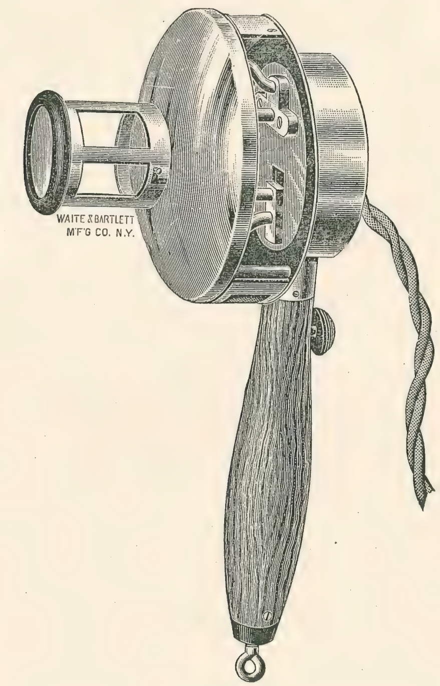

Fig. 25.

The arc may be broken at any moment by simply blowing it out, as one would blow out a candle, and this should always be done before turning off the current at the wall socket. The tube that projects from the front of the lamp carries a quartz plate and is left open on the sides purposely to permit a free circulation of air. The lamp may be furnished in addition with a quartz lens which, mounted in a suitable adapter, will furnish it with either parallel or converging

rays. The strong chemically active light escaping from the sides of the tube naturally impinges on and affects the neighboring parts unless they are properly protected. This may readily be accomplished by means of shields of non-actinic paper. These should be about 3½ inches in diameter with a central aperture of 1½ inches. They may be slipped over the tube before it is attached to the front of the lamp. Should the skin lesion be quite small a suitable diaphragm may be made out of the small disc that is cut from the centre of a larger one. The entire outfit, including the rheostat, weighs about 8 pounds, and may, therefore, be easily carried to the clinic or to the house of the patient if necessary. The author has found, however, that practically this arrangement does not prevent heating. In from 3 to 5 minutes application the heat becomes so intense as to be complained of bitterly by the patient. The iron electrode lamp, modelled after Bang's, can be kept cool, but offers the objection due to the circulation of water. Both, however, are capable of doing good work in the conditions in which iron electrode lamps are indicated.

Freund[1] describes the lamp of Reiniger, Gebbert and Schall, which he regards as an improvement upon Bang's lamp. It is an iron arc light, but 2 arc lights are used, one behind the other. This not only increases greatly the illuminating power of the apparatus, but also works the lamps much more economically, for almost the entire total energy of the 110 volts pressure is converted into 2 light arcs of 45 volts each, whilst in lamps with only one arc of 45 volts, more than half of the energy used is expended to no purpose in overcoming the resistance. By reason of the greater intensity of light thus produced, the duration of the exposures to it are diminished.

Lamps with "electrolyte electrodes" have also been described. These are made of oxides of the metallic earths. They must be heated in order to become conductive, and

[1]Freund Radiotherapy.

this is done by means of an auxiliary carbon arc arranged close to the others. According to the inventor, E. Rasch,[1] this is said to give a pure white light, which is more efficacious than any other arc light.

Bremer[2] has constructed a lamp, the electrodes of which contain a mixture of carbon and fluorspar, which it is not necessary to heat. They are not placed one above the other, as is ordinarily done, but are arranged side by side at an angle with each other; the arc of light directed horizontally between the carbon points is turned downwards by the current, so that it spreads out like a fan. The light from this arc looks yellow and is also highly efficacious.

Vedding's[3] experiments with 2 Bremer continuous-current lamps, of 12 and 60 ampères at 44 and 60 volts pressure respectively, the positive carbons of which were made of a calcium compound, show that the smaller lamp had a maximum illuminating power of 6,400 candles, that the illuminating power was constant below the angles of 45 to 90 to the horizontal, and only then decreased toward the horizontal to 1,000 candles. The second powerful arc lamp had 4 arc lights arranged on the occasion of the measurement in 2 rows. This lamp gave its maximum of 83,000 below 37°. The experiment showed further that with this new lamp 3 times as much light was obtained as in other arc lamps with the same expenditure of energy. It showed advantages over the older systems, even when alternating currents were used. A considerable part no doubt is played in both Rasch's and Bremer's lamps by the gaseous metal compounds glowing in the arc.

Freund concludes that the noxious vapors given by these lamps may probably stand in the way of their being used for therapeutic purposes.

In this connection the following investigation of the subject is of interest, showing as it does how these metallic

[1]Elecktrotechn. Zeitschr. Feb. 14, 1901.
[2]Electroktechn. April 4, 1901.
[3]Ibid. 1900, Part 27. Quoted by Freund.

earths can be used so as to have an increased amount of ozone generated, minimizing thereby the other and objectionable gases.

The electrodes are formed in various ways, the simplest form being a thin carbon tube with or without a coating of tin-foil, magnesia, etc. Barium, strontium, thorium, zirconium and the like are well known as light-emitting as well as oxygen-yielding, and those are selected which correspond to the character of the substances employed in the outer casing. The super-oxids of sodium, calcium, barium, and the like are preferable, as they color the flame. Saltpeter, chlorate of potash, calcium plumbate and the like may be used. The oxygen evolved is immediately ozonized and initiates chemical conversion, and also association processes in the arc by its action on the alkali and carbon vapor; the action being accompanied by considerable heat. The consequence is an intense movement of the ions and a uniformly increased temperature in the arc, and an increased vaporization of the carbon and substances, such as lime, alumina, oxids of barium, sodium or potassium, carbonate of strontium or similar substances. Thus a larger quantity of such gases or vapor is concentrated in the arc, giving increased light and more intense radiation.

The Function of Iron Electrode Lamps.—Before leaving the subject of mechanisms the author wishes to emphasize the fact that the function of iron electrode lamps is limited. With an iron electrode lamp of 25 ampères Bang killed in a few seconds a surface culture of staphylococcus, with a lamp of the ordinary carbon arc, the same number of minutes is required. With such an iron electrode lamp at 1 mm. distance from the face an erythema can be produced in 2 minutes. The iron electrode lamp is very rich in ultra-violet frequencies, but they are very readily absorbed by the majority of media. The light energy from a carbon arc has a power of penetration sensibly greater, estimated by Bang as three times as great as that of the iron arc of the same ampèrage. The action from the carbon arc is more profound.

The iron electrode lamp produces intense reaction at once and from short exposures, but is superficial. The contrary is true of a carbon arc. Each has its own indication, and while their field of usefulness may touch at points the iron arc can in no sense take the place of the carbon arc. A combination is often effectual.

Carbon Spectra Similar to Sunlight.—For the production of a complex of the entire spectrum similar to sunlight but richer in ultra-violet energy, carbon electrodes of the purest and best make are indicated. For the entire range of skin pathology, as well as for all the uses to which the concentrated energy of the arc can be put, carbon arcs of from 25 ampères upwards are to be preferred to iron arcs. When the light is not only concentrated but condensed by means of focal lenses the energy is increased.

Summary.—For superficial effects, the iron electrode lamp as first devised by Bang, for penetration, powerful carbon arcs with condensing lenses of quartz. Bang states that the Finsen apparatus has maintained its supremacy unrivalled in the treatment of deep-seated affections, such as lupus vulgaris. Good results have been obtained with the iron electrode lamp, even in some cases of lupus vulgaris. Kromeyer, Liese, Below, Kattenbracker and Schiff claim to have had good results with the Kjeldsen lamp (an iron electrode lamp) in lupus vulgaris and erythematosus, alopecia areata, eczema, syphilitic ulcers, condylomata, favus and ulcerating hemorrhoids.

Necessity for Absolute Cleanliness of Plates and Lenses of Quartz, of Mirrors, and in Water-cooled Apparatus of Pure Water.—In order to get a powerful light, whatever the mechanism used, it is imperative that the greatest care should be taken that (1) the lenses or plates of quartz, especially the bottom one, are clean and bright. If mirrors are used, the same care should be taken of them. The brighter and more highly polished their surface, the more effective the light energy. (2) The water must be clear and free from floating particles. It should be changed every day. Where the

water is required for a water chamber, as in the Finsen tube, distilled water should be used preferably because of its freedom from impurities. If, however, water is required for circulation, either about a water cylinder, as is also the case in the Finsen tube, or between the two enclosing quartz plates, or as in the Victor lamp, ordinary tap water will answer, but it should be changed daily.

Methods of Use of the Concentrated Energy of the Electric Arc.

To insure success in the use of light energy, as in connection with the use of every therapeutic agent, there are certain important practical points to be considered. Failures are often due to faulty methods as well as insufficient sources of light. First, the source of light selected, if it is desired to cover the entire range of skin pathology, as well as all conditions in which concentrated light is useful as pointed out under therapeutic indications, must not only be rich in those frequencies which are intensely active chemically, but must also give a quantity of light. To this end an electric arc of from 25 to 80 ampères should be selected. If a minor field of action is desired, that is, more recent and superficial conditions, whether skin lesions, septic processes, contusions, etc., a source of light energy of less quantity and more ultra-violet frequencies may be used, as, for example, an iron electrode arc. To meet the same indications, but with a lessening of the field of usefulness, rather than an increase of it, a spark light is indicated. See Chapter XVI.

Need of Compression to Render the Tissues Anæmic.—The physical inability of the short and high frequencies of light energy to penetrate to sufficient depth, to influence well-organized pathological processes, whether a lupus nodule, scar tissue, a deeply seated inflammatory exudate, or a beginning degenerative change in the spinal cord, necessitates the production of an artificial and temporary anæmia of the part to be treated.

Methods for the Production of Anæmia.—In order to render the tissues anæmic, to which the light energy is to be applied, it is necessary either to use (1) a mechanical means, or (2) a suitable chemical agent.

Compression by Quartz or Rock Crystal.—Under the first head come compressors of quartz as practised by Finsen. If the quartz compressor is a lens it should be used at the focal point of light (or a little in front of it to avoid heating), as that is the place of greatest energy. It is because of the fact that the focal spot is the point of greatest energy that Finsen uses focal lenses or condensers in his apparatus. When a Finsen tube or an apparatus constructed on similar principles is used, it is not only the concentrated energy of the light which is being used, but condensed light as well. In focal light mechanisms, accuracy of focus is of the first importance. The area treated is, as a rule, kept well within the focus of the light, but a smaller focus, if it can be borne, has a greater effect. But few of the light mechanisms other than Finsen's in practical use are provided with focal lenses. Instead plates or discs of quartz are used as in the Victor lamp (Lortet and Genoud). The advantages of condensation, as with the focal lenses of the Finsen apparatus are very admirably met in this lamp, and a larger area can be treated at a single sitting than where the light beam passes through a focal lens. But it has not the penetrative power of the Finsen apparatus. If a focussing light mechanism is used, as the marine searchlight, the compressing plate of quartz should be used at the focal point or, as before, a little in front of it, in order to avoid undue heating.

In such a mechanism, the position of this focal spot will depend upon the fixed position of the carbons or electrodes as well as upon the adjustment of the carriage containing the carbon holders by means of the mechanism for that purpose. These may be so adjusted as to secure the focal spot of light from the particular mechanism at a very short distance from the arc, or they may be so arranged as to focalize

the beam of light at a distance of 10 or 12 feet. With this distant focus there is a loss in the highest chemical activity or ultra-violet frequencies, still willemite will fluoresce all along the track of the shaft of light for a distance of 12 feet, the greatest distance tested, showing that all the ultra-violet frequencies are not lost.

Compression by Means of Ice.—Ice is also transparent to ultra-violet frequencies and is an extremely good agent to sift out the thermal rates or wave lengths. Especially is this true in the intra-vaginal use of light in malignant as well as other conditions. It is a simple matter to fill the cylindrical glass spectrum with pieces of cracked ice. Ice may also be used on skin surfaces and its field of usefulness is twofold, in that the parts, when used externally, are rendered anæmic both by pressure and by the action of cold upon the circulation or as summed up by Walsham.[1] (1) It is hard enough to cause efficient pressure. (2) It adds to this effect by increasing the anæmia by cold. (3) By its transparency it allows the individual lupus nodule to be clearly seen and (4) It is transparent to the violet and ultra-violet rays and opaque to the red and infra-violet.

Compression by Pure Rock Salt.—Rock salt is likewise transparent to the ultra-violet rays, and makes a very efficient and cheap compressor. It can be cut in slabs of varying square inch area, and is applicable to the treatment of small or large diseased surfaces. It is capable of assuming a good degree of polish and can be cleaned by wiping off the surface with pure alcohol. As it permits the passage of all the frequencies, thermal as well, it is not so good as quartz or even ice, but it may be used. Marie[2] uses a compressor to which is secured 4 elastic bands, which, by the intermediary of pulleys, are in turn fastened to the 4 corners of a cushion upon which the head of the patient reclines.

[1]Walsham: London Lancet, Feb. 1, 1902. "The ultra-violet light from a rapid oscillation high tension arc for the treatment of skin diseases."
[2]Revue Internationale d'Électrothérapie et Radiothérapie, July and Aug., 1902, Marie.

In this way progressive and energetic compression can be made. A degree of anæsthesia is produced as the pressure is continued, rendering it possible to still further tighten the elastic bands.

Importance of Compression.—This matter of pressure is of great importance, and each individual operator, to be successful, must see that it is firmly, deeply and equably made. The ingenuity of the operator must avail him in the many diverse anatomical localities he is called upon to treat. The object is not to have the active frequencies of light energy absorbed by the blood, and to this end the most complete temporary anæmia is necessary.

The Use of Adrenalin to Render the Tissues Anæmic, Topically and Cataphorically.—The tissue to be treated may also be rendered anæmic by the use of adrenalin. This was first practised by Beurmann.[1] He applied a 1-1000 solution to the part to be treated. In mucous membrane contacts, a piece of absorbent cotton or lint moistened in the adrenalin is applied to the part for from 5 to 10 minutes before using the light. By its characteristic action upon the circulation Freund[2] found from his experiments that it only acts when first applied, i.e., that its effect soon lessens. Both he and Beurmann made a topical application only, however.

In unbroken skin contacts, where there is no contra-indication, a more certain way to secure the desired anæmia from the adrenalin is to introduce it into the circulation by the cataphoric action of the continuous current. Here a piece of blotting paper, or a pad of absorbent cotton of suitable size, according to the area it is desired to deprive of blood, is wet with chlorid of adrenalin, 1-1000 and placed upon the metal electrode or disc, platinum or carbon preferably, although with the small current required block tin may be used. This, in turn, must be connected to the positive terminal of a source of a continuous E. M. F. and placed upon the part while the negative contact is placed so as to

[1]Soc. de dermatolog. et de Syph., July 3, 1902.
[2]Freund, Radiotherapy.

interpose as little resistance as possible to the passage of the current. The negative contact should have sufficient square-inch area to avoid the burning sensation of the current due to too great current density. For example, if the part to be treated is a tuberculous gland of the neck, the indifferent contact, in this instance the negative, is best placed over the upper part of the vertebral column, i.e., including cervical and upper dorsal regions. A contact 2 inches in width by 6 inches in length gives an area of 12 square inches. This distributes the current very well, and permits, if 10 milliampères are used, but 5-6 of a milliampère to one square inch, which is very readily borne. In using the adrenalin to dehæmatize the tissues about the face as well as neck, the indifferent contact can advantageously be applied in the manner directed. The current is then turned on gradually, until the milliampère metre registers from 5 to 10 milliampères of current, and is allowed to flow from 3 to 10 minutes. With the maximum current, the minimum time would be required, but with the minimum current the time would have to be increased. Prior to the application, the skin over the part should be carefully washed with warm soap and water, with alcohol or with a bicarbonate of soda solution in order to remove the oil from the skin. This means lessened resistance or increased conductivity, and with the lessened resistance there is not only a much more prompt diffusion of the adrenalin by cataphoresis into the tissues, but there is much less sensory disturbance experienced by the patient. In practice the author uses mechanical means or compressors of quartz, both focal and non-focal, ice and rock salt, for intact skin surfaces. Quartz is preferred, however.

Size and Shape of Compressing Lens and Plates.—The size of the compressing lens, of whatever material made, should vary according to the size of the nodule or diseased area to be treated. Then again the shape of the compressing lens varies according to the contour of the anatomical locality. If for the cheek, which yields readily to pressure, it should be convex, for the forehead concave, and for the

temples plain. It must be held with firm and equable pressure, as is the practice of Finsen.[1]

Figures 26 and 27 show two compressors for use in treating small areas. The one shown in Fig. 26 is especially useful when an application is called for about the angle of

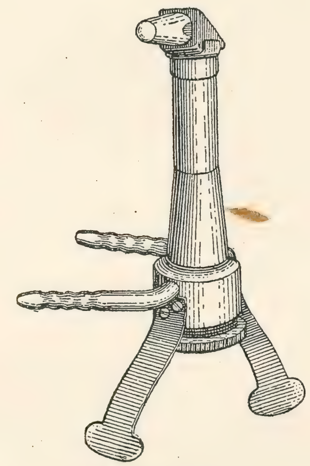

Fig. 26.

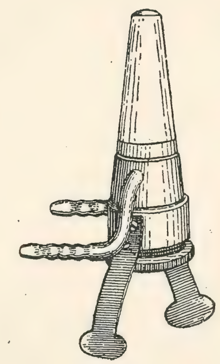

Fig. 27.

the eye and nose. Both are provided with tubes for the inflow and outflow of water.

Length of Exposures with Different Mechanisms. With the original Finsen apparatus the author found it necessary to make exposures from an hour to two hours in length, according to the pathological condition treated.

With apparatus used near the arc itself and without the intervention of cylinders containing water, exposures of from 10 to 20 minutes are necessary. This is true of the Victor-Finsen lamp. With this lamp a 5-minute application will produce an intense erythema, the redness appearing in from 20 minutes to several hours, according to the circulatory conditions of the part. When applied back of the ear directly over the mastoid the erythema appeared in the mini-

[1]Finsen, Schmidt, Berliner klin. Wochenschr., 1901, 32.

mum time, upon the forearm it was much longer in appearing—several hours, in fact. In all cases where it has been used exfoliation has taken place in from 8 to 10 days. The reaction is very marked from an erythema to actual blistering, according to the length of the exposure. With this apparatus 5 minutes should be regarded as the minimum time and 20 as the maximum. In no instance in which it has been used has the author found it necessary to exceed 15 minutes. The same is true of the iron electrode lamps described.

Foveau de Courmelles, Bang and Strebel give the time of exposure necessary with their apparatus at from 10 to 20 minutes.

It is because of the greater chemical light intensity and intense action upon the skin that the shorter exposures suffice. Applications should be made to the most chronic, deep-seated and well-organized conditions daily, selecting different portions of the superfices for exposure on the recurring days. In an extensive lupus growth or epithelioma, for example, two sittings a day may be given in order to promptly bring a considerable area of the diseased tissue under the influence of the light energy.

Frequency of Exposures.—The frequency of subsequent applications will depend upon the amount of reaction and the time consumed in recovery from the same. Complete subsidence of the inflammatory reaction is not to be waited for, as the indication is for the establishment of a hyperæmic process. The same part may need to be irradiated again and again at intervals of a greater or less length of time in obstinate and deep-seated processes. By the action of the light vibrations a stimulus is imparted to the blood stream, increasing its oxygen-carrying capacity; there is an afflux of red blood corpuscles with a corresponding increase of white blood corpuscles, or a leucocytosis. The congestive or inflammatory action thus established, according to the degree to which the physiological irritation produced by the light is carried, results in the death of the diseased cells, and an

increased nutritive activity of normal cells. By successive applications, tissue resistance is increased and healing takes place.

Results Obtained by Frequently Repeated Expenditures of Energy.—In many of the chronic pathological conditions to be treated it is not simply a matter of the amount of a given expenditure of energy at a given moment within the tissues that is necessary to secure the results, but it is its frequent repetition. For example, a man may be easily knocked down and he may pull himself together, recuperate, so to speak, so that it will require as hard a blow or as great an expenditure of energy to knock him down again after a lapse of several days, and with no more lasting results. But, on the other hand, if he is knocked down every 24 hours he has no opportunity for recuperation. In the one instance the work has to be done over each time; in the other, the effect of the previous expenditure of energy (blow) is not lost when the dose is repeated. Therefore, when an expenditure of energy has resulted in a physiological irritation or stimulus of a nature to overcome disease, there is secured by its frequent repetition a steady progress toward the normal, without the slipping back or relapse which is characteristic when this expenditure is infrequent.

In the repetition of light treatment the subsequent reactions are not so severe as the first. A tolerance seems to have been established. This is in part due to the pigmentation of the skin produced by the action of the light. This is a secondary chemical process, and is a protective one. The coloring matter prevents the passage of the light energy.

Necessity for Prolonged Treatment.—Nothing can be more brilliant than the results obtained by Finsen in lupus. Still to secure them means patient and persistent work. For example, the necessary tissue changes can be established which will result in the disappearance of a small lupus nodule the size of a pea, at one sitting from 15 to 20 minutes, when a sufficient intensity of light is used, but this is the exception. Only one small area after another can be treated, and each

has to undergo more or less frequent repetitions of the treatment to secure the desired result. Therefore, the duration of the treatment of a given case is apt to be long. Extensive and long-standing growths will tax the patience of both physician and patient, but the result amply compensates for the time and trouble. To obtain success the requisite medical knowledge does not suffice. In addition there must be an intelligent appreciation of the agent used, and in addition the highest skill and devotion to the work.

Preparation of the Skin for Treatment.—The length of the period over which the treatment extends can in deep-seated lesions of great extent be shortened by following the technique of Finsen, who begins the treatment with the application of a salve containing ichthyol, salicylic acid and pyrogallol, according to the formula of Besnier. By its use, old tubercles become necrotic and by the establishing of this softening and disintegration, the tissues are in much better condition to absorb the light when it is applied. In deeply thickened or hypertrophic areas, a quicker result will be obtained by the use of the pyrogallol ointment. In passing it should be noted that in the treatment of the negro the pigment in their skins is a natural barrier to the easy penetration of the chemical frequencies. Were it otherwise, their ability to live in tropical climates not only without suffering, but in health, would be interfered with. The use of pyrogallic ointment renders the skin smooth and easily penetrable by the light waves, and it should be applied to the part where it is desired to make the application, sufficiently long beforehand to insure this effect. While that spot is being treated by the light, it should be applied to the locality next to be treated in the same way. Morris[1] states that he has used a 5% pyrogallic acid ointment daily for a week, then allowing the part to heal after which the light treatment is resumed. For ulcerated areas or for areas where vesiccation occurs as a result of the treatment, an ointment or salve of either

[1]American Medicine, Oct. 19, 1901.

boracic acid or oxid of zinc may be used to protect them. This should be carefully removed by means of a pledget of lint wet in weak solution of peroxid of hydrogen, of mercuric bichlorid or boracic acid before re-applying the light. Any diseased skin surface involving scabs and crusts should be cleansed before each successive treatment, as it is impossible for the light vibrations to penetrate through their thick horny substance. Under such conditions an expenditure of light energy is valueless. For this purpose a cataplasm of boracic acid should be used. The eyes of both patient and operator should be protected from the light by means of colored glasses for the one and bandaging or colored glasses for the other.

Too great emphasis cannot be laid upon the necessity of properly preparing the parts for treatment. If exposure to the light energy be made upon an indurated horny pigmented skin without such preparation, as is constantly done by unskilled operators, the truth of the remark made to the author by members of the profession, that Finsen's results are not duplicated by other operators, will be substantiated. This condition of the skin indicated effectually prevents the passage of the active frequencies, and no result is obtained, or but little.

The best results are obtained in cases which have not been operated upon. Scar tissue by reason of its imperfect supply of blood vessels prevents the requisite absorption of the active energy, for the result depends upon the absorption of the frequencies which have been known to possess bactericidal and vaso-dilatory powers. A hyperæmia, more or less lasting, is absolutely necessary to the establishment of a cure, not in lupus only, but in many other skin conditions, alopecia areata, favus, chronic acne with hypertrophied nodular tissue, scar tissue and keloid. The same is true in tubercular glands, joints, tuberculosis of the lungs, syphilitic lesions, inflammatory exudates, etc.

In very deep-seated lupus nodules the duration of treatment may be shortened by first destroying them with the

actual cautery. When the reaction established is very profound, treatment should be discontinued until the period of inflammation, absorption and repair has passed, for only then can it be determined whether further treatment is necessary. During this suspension of treatment, however, the case or cases should be carefully watched, for it sometimes happens that isolated and deep-seated nodules remain in evidence. This cannot always be determined until the evidences of reaction have fully subsided. Then, if necessary, one or more supplementary treatments may be given. In the elephantiasis-like forms of lupus sometimes seen on the ears, cheeks, and elsewhere, the reactions may be so severe that they are badly borne by the patient.

During the progress of the case, the course of treatment may be shortened and time saved for the patient by the use of oxid of zinc ointment. In mucous membrane involvement a solution of iodin and iodid of potassium 75%, lactic acid, or the electro-cautery are variously recommended.

Because of the nature of the disease it is necessary to have the patient under observation for long periods of time in order that a re-application of the light can be made in the event of a relapse. The process of cure is well-organized and deep-seated skin conditions is not a rapid one. It is slow but sure.

Technique of Finsen's Lupus Treatment.[1]—At the Finsen Light Institute each patient has his own attendant, whose business it is to direct the light constantly on the diseased spot. The patient lies on a suitable couch with his head raised, or sits in an armchair with a head rest. The time of the application (sometimes two hours) is too long for a patient to remain immovable. His eyes are protected by a cloth, the attendant's by darkened glasses. Any scabs or crusts are first softened, and then removed with forceps, and the part is washed with a weak antiseptic solution, 3%

[1]Finsen's Technique as given by Freund in "Radiotherapy."

boracic acid, and dried. The beam of light is then directed to the disease, and care is taken that the axis of the beam of light is perpendicular to the area illuminated. The part to be treated is not placed directly at the focus, but a little in front of it, so that not one point of it, but a small circle, is illuminated. In this way there is less danger of the skin becoming heated. A circular area having a diameter of 2 cm. may be treated at one sitting. The surrounding parts are covered with wadding or yellow paper. A suitably shaped compressor is placed on the diseased spot, and held there firmly with equable pressure. The shape of these should vary according to the part to be treated, as has been pointed out. The duration of the sitting varies according to the quality and intensity of the light used. Finsen recommends a 2-hours exposure with his concentrator and a lamp of 30 ampères. With lamps of 80 ampères the time may be cut down to an hour and a quarter. With these powerful lamps Finsen found 13 to 20 minutes' illumination to affect a definite cure of lupus nodules the size of peas. The patient suffers no pain during the irradiation except when the pressure is applied to ulcerated or bony parts, for example, near the nose. After the treatment, symptoms of erythema solare appear. The irradiated parts become a little red, the redness very soon increases markedly, and at the same time slight swelling shows itself, and burning pains are felt, the skin becomes softer and unevennesses disappear. Within 24 to 48 hours later a large blister forms, filled with serous fluid. This dries away in 6 to 8 days to small readily demovable scabs. There is never any loss of substance below the blister. When the blister is exfoliated considerable redness is left, which only passes away after months. To prevent infection of the blister a dressing is applied of boracic lotion or zinc ointment. After a week or fortnight, when the reaction has disappeared, and the scabs have fallen off, the same place may be irradiated again, later even more than once; in fact, this is necessary if the therapeutic effect is to be lasting. When one spot seems to have been sufficiently

treated the neighboring spot is to be treated in the same manner. In this way the treatment proceeds from spot to spot until the whole part attacked has been exposed to the influence of light. The treatment should begin at the periphery of the lupus region, and the light must be so directed that in each area of illumination a piece of apparently healthy skin in the immediate neighborhood is also included. After the sitting the spot is marked with a pencil, then the dressing is applied.

The compressor having been cleansed with ether, alcohol and a solution of carbolic must be steeped for an hour in carbolic, and then placed on the side filled with distilled water. The rock-crystal lenses of the concentrators are cleaned once or twice a week with ordinary water, and afterward rubbed with cork. Those nearest to the carbon points are further brushed down thoroughly after each sitting, and covered with flannel caps to prevent too rapid cooling and consequent cracking.

Finsen, whose experience in the treatment of lupus by the means of light is far more extensive than that of any other operator, has established the time necessary for lupus cases to be under treatment at from 4½ to 6 months.

The cosmetic results from the use of light are most satisfactory. There is no destructive action as with chemicals, the cautery or the X ray. On the other hand, there is a constructive action from the beginning, induced by the conservative action of light. There is no untoward action when the apparently healthy tissues around the diseased part are also subjected to the action of the light. Healing takes place without any scar tissue whatever, the scales, thickness, hardness of the long-standing infiltration, characteristics of such chronic skin lesions, lupus erythematosus, vulgaris, acne, etc., disappear, and the skin becomes soft and elastic, with a smooth surface like the rest of the skin. There remains in some conditions a brownish reddish color, from the persistent and long-standing congestion, and due to the diseased process. The reaction established by the

action of the chemical frequencies of light upon the skin is in the milder doses scarcely if at all apparent. With greater condensation and longer applications it becomes more marked, and usually appears the day following the application. Unlike the Roentgen ray, it appears and disappears quickly, and leaves no destruction of tissue or untoward result of any kind. With the former, the period of incubation is everywhere from a week, 10 days and upwards, and the areas acted upon are extremely difficult to heal. From the use of light the reaction established is characterized by the degree of redness more or less profound and swelling. This reaction is from that of a simple congestion to one of inflammation, depending upon the degree of energy of light values used, as well as the time of exposure. There may be considerable œdema. The reaction lasts but 4 or 5 days, when it disappears, leaving the surface of the skin smooth, and of normal characteristics. There remains a little pinkish coloring for a few days longer. The light treatment causes no pain. A red erythematous spot and blister appears where the light is applied, and in 5 or 6 days the scab falls off, and the ulcer is healed beneath, and the skin is left free from scar or cicatrix, but red. The red fades away after a variable period, and leaves the skin white and uncontracted beneath, save where there has been a loss of tissue from the disease before treatment. The difference between the appearance of the skin from the use of the X ray and from the use of the light is very marked. With the former there is a retracting or drawing of the skin due to the atrophic changes established in the skin follicles, sweat glands, oil ducts, and hair follicles. With light there is absolutely no wrinkling of the skin, no atrophic changes, but a perfect smooth white, or pinky white condition. If the treatment has been given to an unbroken lupus nodule, for example, there is absolutely no scar tissue, but if to an ulcerated lupus vulgaris, a syphilitic ulcer, while the cosmetic effect is just as good, and there are no atrophic changes, there is the little pucker or scar due to lost tissue.

Involvement of Mucous Membranes.—Even when the lupus process attacks the orifices of the body, as the mouth, gums, palate, or the nose, this method may still be used but not with as good results as with skin surfaces. Morris[1] and Dore consider involvement of the nostrils, mouth, a contra-indication to the use of the light treatment. According to Forchhammer, the relapses occurring in lupus cases after treatment are generally among those patients who neglect to report at the end of the treatment; or where there is extensive mucous membrane involvement. Any severe intercurrent and debilitating disease, as influenza or erysipelas, may also operate to cause a relapse.

Contra-indication in an Isolated Instance.—In a case treated by Brocq,[2] exposure to the light energy always produced the most violent eczema and œdema, so that it could not be used. This is unusual, for its action is eminently conservative, not only in that it is readily borne, but that it spares healthy cells.

Conditions Influencing Prognosis.—Too great an emphasis cannot be laid upon the fact that scarring, pigmentation, vascularity, great depth below the surface, the situation of the disease near the eye, on the eyelid or on the mucous membranes, as well as great extent of the lesions, are factors which unfavorably influence the prognosis.

But while this is true, it need only be remembered that Finsen is authority for the statement that not more than 2% of lupus cases need be regarded as incurable.

The Choice between the X Ray and Light Energy.—As to the choice between the X ray and light energy in the treatment of lupus, the author believes it lies with light. The X ray possesses drawbacks, in the dermatitis produced by it and the atrophic changes in the skin which sometimes follows its use. It is not the province of this volume to discuss the value of the Roentgen ray in lupus. It has a place of very great value, but wherever the lupus process is one

[1]American Medicine, Oct. 19, 1901.
[2]IV. Intern. Cong. de Dermatologie, Paris, 1900.

that can be controlled by the action of light energy, to it should be given the preference. The time required where cure results is perhaps not any less for both light and X ray treatment than with other classic measures, but they are both conservative, the light eminently so. It is practically painless in the average case and insures the best of cosmetic results. The strongest plea for the use of light energy, if plea it needs, is not only that it cures, but it cures safely.

Conclusion: It is not necessary to corroborate Finsen's work in lupus vulgaris by that of any other. It stands unparalleled and needs neither proof nor disproof.

In skin pathology, however, there is a very wide range for the use of the concentrated energy of the electric arc other than lupus vulgaris.

In the following conditions concentrated energy of the electric arc spectrum has been used with considerable degree of success: Lupus erythematosus; chronic acne, vulgaris and rosaceæ; sycosis, parisitaria and non-parasitaria; superficial epitheliomas; eczema; psoriasis; alopecia areata; favus; syphilitic ulcers; condylomata; nævus vascularis; furunculosis; rhinophyma; biskra-button and septic processes.

The literature of the past few years contains reports of the treatment of these various conditions, with varying degrees of success by different operators.

For eczema, psoriasis, syphilitic ulcers and septic processes, the author, judging from such clinical experience as has been afforded, believes that light energy acts almost as a specific. The results obtained are not only dependent upon the suitability of the source of light energy, but upon the care and skill with which the work is done. The use of this agent is no exception to the universal rule, that everything depends upon the intelligent skill with which it is used.

Vegetable Parasitic Diseases, Ringworm, Favus, Pityriasis Versicolor and Sycosis.—M. Marie reports a case of sycosis involving both cheeks, which healed admirably from a single exposure, of from 10 to 15 minutes' duration, to the

concentrated energy of a 60-volt and 15-ampère arc, in which the carbons were placed at right angles, the negative smaller than the positive and regulated by a hand-fed mechanism. In this way there was secured the light of the *arc* or blue mist, the crater serving as a reflector. The active frequencies were concentrated upon the part to be treated through the media of quartz plates, the patient being placed very near the source of light. Leredde[1] also reports a case of chronic sycosis cured with light and Gerson[2] and Von Ziemssen[3] noted good results in ringworm, favus, sycosis and pityriasis versicolor.

G. M. Müller, Strebel and Barbensi[4] have treated sycosis parasitaria and non-parasitaria by means of light energy.

From the action of the X ray in this disease the inference is drawn by the author that light should be effective. Sufficient data has not been accumulated as yet nor have the results been sufficiently definite and certain to assign to light energy a positive place in the management of sycosis.

Finsen's[5] cases of favus gave negative results and up to 1901 he had reported but two cures, recent cases, in six ringworms of the scalp in children.

Lupus Erythematosus.—Finsen, Bang, Forchhammer, Leredde, Petersen, Sabourand and G. J. Müller have tried treating this condition with the concentrated energy of the electric arc. They have found it to act satisfactorily in fresh cases, but in cases of longer standing and especially if the lupus erythematosus is generalized, it often has no effect.[6] Lesser[7] had less favorable results in the treatment of lupus erythematosus than in lupus vulgaris. They were less certain.

[1]Leredde: Presse Medicale, Sept. 7, 1901.
[2]Gerson: Archiv. für Lichttherapie, Vol. I., No. 3, 1899.
[3]Von Ziemssen: Festschrift zur Feier des 50 Jährigen Bestehens des Ärztlichen Vereins Nürnbergs; Monatshefte für praktische Dermatologie, June 15, 1903.
[4]Quoted by Freund.
[5]Finsen, Niels R.: Mitteilungen, etc., 1899, 1900, 1901. Bie's translation.
[6]Quoted by Freund.
[7]Zeitschrift für Diätetische und Physikalische Therapie, Lesser, Berlin, 1901-1902, Heft 16.

This was also the experience of Petersen[1] and is corroborative of Finsen's experience as well as that of many others. In the author's experience a case of lupus erythematosus involving nose, both cheeks and ears, associated with chronic eczema and with extensive infiltrations of the lobes of the ears, improved to a very marked degree under the influence of the concentrated energy of the arc alone. Complete recovery from the lupus erythematosus, however, did not take place until the parts were exposed to the Roentgen ray for a few times. Leredde[2] reports 3 failures, 3 improved and 11 completely cured out of a total of 23 patients, while 6 more exhibited a "segmentary cure," that is, one patch was cured. To appreciate the value of these results he gives the following résumé of treatments previously inflicted upon these patients: Galvano-cauterizations 802 séances; scarifications, 382 séances; high frequency currents 462 séances. None of them had even a single patch cured by any of these measures. Sometimes the most hopeless cases apparently were the most rapidly cured. Leredde thinks the light treatment should be pushed until the formation of cicatrices. In this connection he states that it is likely to fail in the vegetating elephantiasic type of lupus or where there is deep sclerosis, unless the field can be cleared for the action of light (currettement might avail here) before its use. In lupus of the trunk or limbs healing may take place more rapidly under the use of other measures owing to the existence of a plane of hypodermic cleavage, which generally prevents the progression of the lesion into the depths. Every case of erythematous lupus should receive energetic treatment from the start. Finsen has demonstrated that the longer it lasts the deeper and more rebellious it becomes. Radiotherapy should be tried if concentrated arc light energy fails and in certain regions ablation might be indicated.

[1]The Success of Light Treatment, Petersen, Vratch, Nov. 10, 1901, Vol. XXII., No. 43.
[2]Leredde: Indications and Contra-indications for Phototherapy, Journal American Medical Ass., June 21, 1902.

During a course of treatment by light all scarifications should be avoided, as the formation of scar tissue is inimical to the penetration of light.

Gaston[1] reports 3 complete cures and several partial cures in 10 cases of lupus erythematosus.

Morris and Doré[2] of 6 cases of lupus erythematosus reported 2 cures, 3 discontinued and one under treatment at the time of the report. Of the successful cases one of 15 years' duration was very extensive and superficial. The areas covered by the disease were after treatment occupied by a fine white scar. In the other the disease was more chronic, less superficial and there was deeper scarring.

Hyde and Montgomery[3] report 9 cases of lupus erythematosus treated long enough and with sufficient regularity to note results and state that they found the treament of undoubted value. With one exception their results were better from the use of the concentrated energy of the electric arc than from the X ray, though both methods were tried in several cases. The lesions were on the face, nose, eyelids, forehead and ears, and were of from one and one-half to five years' duration. In their work an area one inch in diameter was treated at each sitting of 15 minutes' duration. The intervals between the sittings varied from 5 to 14 days. From 2 to 4 hours after treatment there are some anomalous sensations, such as pricking or stinging. These occur from the use of the light in any condition and are often experienced much earlier and last for a much longer time.

Those lupus erythematous lesions in which the vascular element predominates yield most readily, some of them disappearing after 2 treatments. On the other hand cases in which the sebaceous element predominates are the most obstinate.

[1]A year's experience with phototherapy, Gaston, ibid.
[2]The Lane Lectures on the Social Aspects of Dermatology, Malcomb Morris, London, American Medicine, Oct. 19, 1901.
[3]Radiotherapy and Phototherapy, Hyde and Montgomery, Jour. Am. Med Ass., Jan. 3, 1903.

While the effects in lupus erythematosus are strikingly inferior to those in lupus vulgaris, still they are sufficiently favorable to warrant the use of energetic and prolonged light energy. The justification of this is to be found in Leredde's experience.

Eczema.—This is also a condition which lends itself to the action of light energy. By means of concentrated and condensed arc light energy, a patch of eczema of the axilla was completely cured by one exposure in the author's practice. The use of light energy in eczema has also been considered under Electric Arc Light Baths.

Hellmer[1] reports an extensive pustulo-crustaceous case of 2 months' standing cured with 7 exposures. Good results were obtained by Minim[2] in a case of chronic eczema of the face. In this operator's hand the visible chemical frequencies of concentrated incandescent light were used.

Gerson[3] also reports satisfaction with the results in eczema from the action of light energy.

Finsen has reported but a small percentage of cures in chronic eczema from concentrated and condensed light energy.

Acne Vulgaris.—In the author's practice marked improvement has been obtained in the most extensive and longstanding cases of this sort, cases in which pimples, pustules, nodules, pitting, thickness of the skin and deep infiltration of the tissues were associated. Treatment has been interrupted in this grave class of cases before a complete cure was accomplished. Light energy has served, however, to improve the condition where all other means have failed. The concentrated energy of the electric arc has been used with compression, and also the electric arc bath. Given but the one means to the end the author considers that the choice lies with the general rather than the local administration of

[1]Hellmer, Ernst: Blätter für klinische Hydrotherapie, No. 7, 1901.
[2]Minim, A. B.: Medicinische Wochenschrift, No. 12, 1901.
[3]Gerson, ibid.

light as a systemic fault, or vice always lies at the bottom of this facial condition. Finsen reports a small percentage of cures in acne vulgaris from the use of the concentrated energy of his 80-ampère carbon arcs.

Acne Rosacea.—Leredde[1] reports 8 cases. In mild cases he does not believe it best to resort to the use of light energy because of the expense attendant upon it. In longer standing and more deeply infiltrated cases of the disease, he finds that the use of light offers undeniable advantages, when associated with the necessary treatment of the visceral troubles, particularly troubles of the gastro-intestinal tract.

Acne Rosacea of the nose lends itself especially to treatment by light because of the depth to which the diseased process extends. This is not so true where the cheeks are involved. Leredde does not hesitate to employ scarification where chemical methods have failed.

The author has had but little experience in the treatment of acne rosacea by the means of the light energy, but in the improvement obtained in this class of cases from the use of the continuous current, is prepared to believe that much can be accomplished by the use of light. In their deeply penetrating chemical action, the two, i.e., the light energy and the continuous current, are comparable; but the former produces its characteristic action upon the skin and superficial blood vessels, with the best of cosmetic effect; while the latter, when of sufficient intensity to produce the same changes, acts destructively upon the skin, causing scar tissue.

Epithelioma.—There is considerable and reliable data, showing that in superficial epitheliomas, concentrated light energy is of avail, but there are many other classic measures that are undeniably of equal value. Still as a production of scar tissue is to be avoided, whenever and wherever possible, preference should be given to light in this class of cases. In 16 cases of epithelioma of the skin, treated by

[1]The Treatment of Rosacea, Leredde, Rev. Prac. des Mal Cutanées, Aug. 1, 1903.

concentrated light energy and reported by Bie,[1] there was in 3 cases no improvement; in 5 cases improvement but not cure; in one after apparent cure speedy recurrence, while in 7 the result was described as a cure, which had been maintained respectively for 2½ years, 11 months (2 cases), 9½ months and 6 months (3 cases). From this experience Finsen concluded that the cases of epithelioma, which respond to the action of light energy are, as has been stated, superficial well-defined forms in accessible localities. Distinct improvement has been seen in the treatment of this class of cases by Petersen, Bugesdorf and others. Preference is given very justly to the X ray by all investigators.

In a case of recurrent epithelial nodes upon the nose of a woman, aged 70, in the author's practice the energy of an iron electrode arc sufficed to produce absorption of two-thirds of one of the nodular masses, and all of the other. To secure absorption of the more deeply infiltrated tissue of the remaining third of the larger nodule, the deeply penetrating frequencies of a 25-ampère carbon arc, condensed by the means of focal lenses, sufficed.

Alopecia Areata.—This is also a condition which theoretically lends itself to treatment by light energy. It is believed by many dermatologists to be of a parasitic nature, and the condition is one demanding the production and maintenance of a hyperæmia, if good is to follow. The bactericidal action of light, its ability to excite tissue reaction, and the stimulating effect consequent upon the skin inflammation all suggest the applicability of light energy to the treatment of alopecia areata.

In the first report[2] of the work of Finsen in English, published simultaneously in England and America, mention is made of the use of light energy in alopecia, and 7 cases were reported cured. These were first published in Danish, January, 1899.

[1]Malcom Morris, Social Aspects of Dermatology, Lane Lectures, American Medicine, Oct. 19, 1901.

[2]Finsen's Phototherapy, Vlademar Bie, The Philadelphia Medical Journal, Oct. 7, 1899, and British Medical Journal, Sept. 30, 1899.

The following detailed report was made at that time: A patient, aged 15, in the beginning of June, 1897, noticed a bald spot about one cm. in diameter which was steadily increasing. When the treatment was instituted September 3, 1897, there was a large completely bald spot of 6 by 4 cm. The areas immediately surrounding the diseased area were shaved, and afterwards 8 treatments were given of a half an hour each, from September 3 until September 24. On October 4 lanugo hair was noted in the patch. November 5 a normal growth of hair. January 12, 1898, a bald spot $2\frac{1}{2}$ by 2 cm. was seen. From January 12 to 16, 5 exposures, an hour each in duration, were made. January 22, fine small hairs noted. March 29, the growth of hair is as vigorous as on most of the scalp. On October 22, 7 months later, the condition remained the same.

According to Freund, O. Jersild[1] first suggested the application of light energy to the treatment of alopecia areata. The reports of Jersild were very encouraging. Gottheil[2] mentions 2 cases in which extension of the bald areas stopped and lanugo hairs began to grow within 3 weeks after beginning treatment. In a later report of the work done at the Finsen Institute by Forchhammer, 30 cases out of 49 treated were cured. Sabourand in a personal letter to Freund reported a much less successful experience; in active cases of alopecia areata no good results were obtained by the use of concentrated light energy, but in chronic cases, limited in extent success was met with. The method of application is practically the same as for lupus vulgaris. A powerful source of light energy is necessary, and it should not only be concentrated but condensed by means of focal lenses. Before exposure the parts around the bald spot must be carefully shaven, for from one to 2 cm. The judgment of the individual operator must govern the extent to which this

[1]Annals de Dermatologie, 1899, p. 20, quoted by Freund, Radiotherapy and Phototherapy.
[2]Gottheil: Georgia Journal of Medicine and Surgery, June, 1902.

should be done. The first exposure should be made to the periphery of the healthy part in order to prevent further extension of the disease, and to advance toward the centre. From one to two exposures should be made daily according to the condition of the given case, and for an hour and a quarter each. The closeness of the scalp in relation to the skull, renders compression of less importance than when soft tissues are being treated, and Jersild found compression unnecessary. In his practice he kept the skin cool by wetting it with cold water. The author would suggest here the use of a smoothly cut slab of ice. By simply resting on the part the skin would not only be kept cool but anæmic as well, and the light energy at the same time be permitted to pass. There should be no pain attendant upon the treatment. Exposures should be made only once to each diseased spot until the amount of reaction as well as result is known.

The first thing noted as the result of treatment is that the hair stops falling off from the part treated; later lanugo hairs appear (according to Jersild, at the earliest after 11 days) in longer or shorter time on the bald patches which gradually become pigmented and thicker. Lesser[1] also noted favorable results from the use of light energy in alopecia areata.

Theoretically it would seem that the best results should follow the more recent origin of the disease. In cases of many years' standing it simply follows from the nature of the pathology that no good results should obtain; for the longer standing the more complete the destruction of hair follicles. No matter what the pathological condition, whether involving the structure of nerves, glands or hair follicles, degenerative changes fully established are absolutely beyond the expenditure of any form of energy, no matter what its value where the process is not yet complete. Degenerative changes may be arrested in the one instance or the other, but a hair follicle, for example, once destroyed, cannot be restored under any circumstances.

[1]Ibid.

Rodent Ulcer.—Morris[1] reported seven cures in thirteen cases of rodent ulcer. Two had been subjected to excision, prior to treatment by light; the X ray was used to finish the treatment in the case with the most extensive involvement, having had 35 exposures of light energy first. Of the remainder 5 recovered in from 7 to 22 exposures; while of a case of small rodent ulcer in a man aged 83, 2 years' duration, inner canthus, right eye was treated for 7½ hours with success.

In a very extensive rodent ulcer involving loss of the scalp 4 to 6 inches in diameter, and also the skull plates (arsenic paste), the author found an exhibition of light energy a valuable adjuvant to the X ray treatment, in controlling pain, discharge and stimulating granulating tissue. For a time this patient improved, but a year after coming under observation died from exhaustion following a rupture of a blood vessel and consequent hemiplegia.

Nævus Vasculosus.—Light energy seems to recommend itself as of especial value in the treatment of this condition. The process of repair following upon the endo-vasculitis, established by the action of light energy, is a rational explanation of its action. This endo-vasculitis is followed by an obliteration of the vessels themselves, as was established by Sack. Pusey regards it as a better agent than the X ray. The deep red color of the diseased area is reduced by the action of the light in most cases, according to Forchhammer, while in some cases complete cure is established.

It was observed by Peterson in a case in which the nævus extended from the forehead to the eyelid that there was improvement not only in the part of the forehead treated, but also on the part of the upper lid, which because of its relation to the eye was not irradiated. This should be expected for the action on the larger vessels of the forehead would unquestionably influence the contributory area.

Lesser[2] has noted a favorable result from the use of con-

[1]Ibid.
[2]Lesser, ibid.

centrated arc light energy in telangiectasis. The author should expect good results to accrue from an expenditure of the chemical energy of the arc in cases of nævus vasculosus simplex or simple angioma in the various forms known to the laity as "port-wine stain," "strawberry-mark," or "mother's mark." These occur in smooth, flat, non-elevated or very slightly raised well-defined or faint patches. As they occur in children or even from infancy to adolescence they should yield to the action of light energy. The younger the subject, the better the result should be, for the skin of these young subjects is very soft, smooth, thin and unpigmented, conditions which enable the effective frequencies of the arc to penetrate more readily than later in life, when the skin becomes thickened and pigmented. As the treatment is absolutely painless, it lends itself to the treatment of young children.

In the second variety of nævus vasculosus, or angioma cavernosum, light energy theoretically does not seem to offer much. Great vascularity is a contra-indication for its successful employment, and this variety of vascular nævi is characterized by great vascularity. It occurs as a prominent, turgescent, erectile, or even pulsating tumorous-like growth enlarging during crying or other emotional disturbances. There would be no danger in attempting the treatment of cavernous nævus in the manner even though no result is obtained.

In nævus pigmentosus, or pigmentary mole, those of smooth surface, slightly elevated above or level with the surrounding skin, might be readily acted upon by the concentrated electric arc energy; the pigmentation would however interfere or modify the penetration of the light energy. In the other varieties of pigmentary moles the author uses the electrolytic method in preference to all others.

Leprosy.—The good effects obtained from the treatment of the superficial lesions of tuberculosis, and the more superficial malignant skin conditions from the use of light are certainly very suggestive of possible benefit from its use in the

treatment of leprosy. As a bacterial disease leprosy has some peculiarities indicating the possible utility of light; it is mainly confined in its manifestations to the parts of the body that can be reached and its microbe, judging from its apparent feeble contagiousness, is not in all respects resistant to hostile influences. Sequeria has observed some action in the lesions of tubercular leprosy, but experience in this particular direction is thus far limited.

As a disease, notably characterized by deficient oxidation, the short and high frequencies of light energy, especially the complex of violet and ultra-violet, are, theoretically at least, indicated. The author suggests that in the event of the opportunity offering leprous lesions should be so treated.

It is not only in medical cases but in surgical as well that the action of light energy is effective.

In infectious processes it is of great avail and in it there is to be had an agent which is at once bactericidal, antitoxic and resolvent.

Septic Processes.—The opportunity has offered for the use of the concentrated energy of the electric arc in minor septic processes. The following very illustrative case of blood poisoning, due evidently to the bite of an insect on the middle of the dorsal surface of the foot, just over the arch, may be instanced in this connection.

There was systemic infection, as evidenced by chill and fever. The lymphatics from foot to groin were swollen, red, hot, and painful. There was also four to five days later on in the history of the case, an intense localized inflammatory action at the site of the bite, with the characteristic boggy feel of a deep-seated suppurative action, co-existent with the most extensive cellulitis of the entire dorsum of the foot which the author had ever seen. The skin was literally stretched to the fullest extent, presenting a very smooth and glossy appearance. The patient was unwilling to have it laid open when seen at his home, because of the position just under the shoe lacing and the consequent

disability. He was, therefore, placed in a carriage and brought to the author's office, where a single exposure to all the chemical frequencies from the blue into the ultra-violet, of a 25-ampère carbon arc (the special adjustment of the marine searchlight mechanism), was made. The concentrated energy of the arc was used at the focal spot, through a condensing lens of quartz, which served as a compressor, for 15 minutes. At the end of the exposure, the pain, swelling, soreness, and immobility had practically disappeared.

A subsequent application was made on the following day, as a matter of precaution, although the patient stated that his foot was "perfectly all right." He had on this second visit only accompanied his wife, who was under care, to the office.

The tissues under the compressor remained analgesic and indurated for several days, but both of these conditions disappeared. A single localized application of the convective discharge of the franklinic current hastened absorption. There was no further trouble, and the troublesome open sore with the formation of scar tissue was avoided.

Similar satisfactory results have followed the use of concentrated arc light energy in septic processes originating at the site of hair follicles in a case of carbuncle and involving the subcutaneous cellular tissue. The carbuncle had been opened and the arm and hand exposed to the action of the X ray prior to the patient, a physician, coming under observation. He had been ill for from two to three months when he came under the author's care. The original lesion had healed, but constantly successive crops of pustules appeared, apparently superficial but in reality very deep-seated. Each one had to be opened before healing could be established and each in turn was followed by another and another, all going on to the suppurative stage. The arm and hand had subsequent to the X ray been treated by means of hot air but without relief. The patient was thin, worn, cachectic and ill able to get about. The case was referred as one of sepsis

believed to be due to the character of cases the physician had been handling in his practice.

In a study of the conditions during the time the case was under observation, the author became convinced that the process was secondary to the use of the X ray, rather than a septic condition secondary to the carbuncle. Suffice it to say, however, that no foci of inflammation went on to suppuration after treatment was instituted by means of light. Each pustule was treated by means of the concentrated energy of (1) a carbon arc or (2) of an iron arc, according as to whether he presented himself at the author's private office or at her teaching clinic, for from 5 to 10 minutes; compression being used in either event. The carbon arc was given the preference, and there was conjoined with it upon the days he visited the office a 20 to 25 minute exposure of the upper nude body in the electric arc bath, because of his systemic condition.

In all there were from 6 to 8 exposures to the combined action of the concentrated light energy and that of the light bath.

Improvement began immediately, and every inflammatory pustule was aborted. The wounds from previous incisions healed rapidly, the skin became normal, the arm mobile and the patient's general health improved most rapidly, as evidenced by improved circulation, good skin coloring, increased appetite, better digestion, gain in weight and strength. All told he was under observation but 10 days, and during the latter part of that time not for the treatment of the arm, as the necessity no longer existed, but for the purpose of establishing the best possible condition of the general nutrition.

Tubercular Joints.—Tsiechauski[1] has reported eight cases of tubercular joint conditions successfully treated with the energy of the electric arc. He used arcs of from 80 to 100 ampères at 35 to 40 volt pressure or light of 12,000

[1]Prakt. Vratch, Aug. 31, 1902.

candle-power. From his experience he concluded that the complex of energy represented by the electric arc in the treatment of articular tuberculosis gives favorable results, is absolutely painless, and replaces altogether all the other methods of treatment.

It must always be kept in mind that the radiations of the electric arc, like the radiations of solar light, are carriers of energy, and when intercepted as they are by the interposition of the body (as a whole or a part, as in a tubercular joint) they do work, producing heat, vision or chemical action according to circumstances. In this instance the action is twofold, i.e., the thermal effect and the chemical effect.

Each in turn undergo still further modification in effect within the tissues dependent upon their action upon the superficies, determining chemical, osmotic and molecular changes of a nature favorable to the promotion of the nutrition not only of the part, but of the entire organism as well.

The author personally has had no opportunity to use light in tubercular joints, but from experience with tuberculosis pulmonalis, is of the opinion that light energy should avail much in this class of cases. The experience of Kaiser with the visible chemical frequencies need only be recalled to emphasize this statement, viz., the cure of tubercular abscesses of the thigh by chemically active light energy. For this purpose the parallel or converged rays of electric arc should be used directed against the part to be treated.

A mechanism by which the rays may be converged upon the part, as in the marine searchlight, is indicated. The arc should consume at least 25 ampères. A higher ampèrage with the larger carbons means a greater unit of area of light and a source of greater energy. The duration of the exposures should be from 20 to 45 minutes, according to the patient's tolerance and from once a day, at first, to three times a week later on, the nutritional changes governing the operator as to frequency and length of treatment. Every tubercular patient, whether it is a joint or lung case, should receive not only the topical but general treatment as well.

To this end the entire superficies of the body should be exposed to the action of the light as well as the joint.

In deeply involved and infiltrated joints the use of adrenalin cataphorically is advised. By the use of a large block-tin contact, placed over the lint or cotton wetted with adrenalin 1-1000 and attached to the anode, the entire knee or elbow for example could be dehæmatized to such an extent as to secure greater penetration of the energy of the arc and therefore more profound and lasting effects.

The use of an Esmarch bandage is recommended by Freund for the purpose of rendering joints anæmic. As the joints in young children are very transparent he states that they could readily be made bloodless in this way. From the author's experience with tuberculosis pulmonalis, it does not seem that it is necessary to render the part absolutely anæmic. If the blood is cut off from the more superficial tissues there is opportunity offered, however, for a greater action of the light energy, an action which in turn is capable of influencing deeper tissues.

According to Freund, G. Hurtado[1] claims to have cured arthritis tuberculosa in the elbow by this means. The use of light energy has also been recommended by Finsen in tubercular joints, where the tissues can be rendered partially or completely anæmic.

To every one equipped with suitable sources of light energy, the author would recommend its use in this class of cases. Especially would it be desirable that such work should be done in orthopedic hospitals and practice in order to establish the true value of the method.

The treatment of tuberculous joints is also referred to under the use of solar light energy.

In the electro-therapeutic laboratory l'Hôpital de la Charité of Paris,[2] a child 11 years old with tubercular

[1]Freund, Radiotherapy, p. 572.
[2]The Phototherapy of Adenitis and of Tubercular Arthritis, Revue Internationale d'Électrothérapie et Radiothérapy, Jan., 1904. Abstract from La Semaine Medicale.

arthritis of elbow complicated with a fistula was treated by means of light. In five months the cure was complete. It was noted that on exposure of the diseased parts to the light of electric lamps, placed at a distance less than 20 centimetres, there would be immediately a diminution of pain, of stiffness, and of the functional disability, so that slight movements of flexion and extension of the diseased joint, which could not be practiced before without causing acute pain, became possible and provoked only a very slight painful sensation. This amelioration continued up to resolution. The author admits that where the lesion is already advanced its progress would not be stopped by an expenditure of light energy, but that it would go on to suppuration. Favorable results follow its use, however, in diminishing the sero-purulent oozing and in preventing the formation of the extensive fistulous tracts, that one often sees in surgical tuberculosis.

This author concludes that in the use of light in these conditions, as in treatment of all dermatoses, the rays ought not to be pushed to the production of phlyctenules; they seem to carry an obstacle to the deep penetration of the radiations, forming a sort of isolating glaze.

Chronic Synovitis.—In inflammations involving the articulating surfaces of joints and the synovial membranes light energy should be of great avail. The more recent the condition, the more promptly and completely will it yield to the use of light. This is by reason of the fact that the products of the inflammatory action are not well organized and circulatory changes, with consequent absorption, are more readily established.

At this writing a case of chronic synovitis, involving the left knee in a woman, aged 60, of from 3 to 4 years' duration, due to an injury is under care. The contour of the knee was changed from the normal, the entire joint much enlarged, fluid under the patella and in the bursæ, extreme roughening of the articular surfaces, pain on movement, great disability and inability to put the heel to the floor on first rising. In this case the continuous current was used at first with the

hope that absorption might be stimulated. There was no appreciable effect from some six applications, however. The joint had been treated with hot air, i.e., baked prior to the patient's coming under the author's care. Treatment was then instituted by means of the concentrated energy of the marine searchlight, at a varying distance of from 6 to 8 feet, and the mechanism adjusted so as to bring the parallel rays to a focus at that distance and the size of the focal spot sufficient to cover the entire joint area. The sittings in this case have only averaged one a week as the patient is unable, because of the heat and the fact that she is at her country home, to come oftener without too great fatigue. Each exposure has been from 30 to 45 minutes in duration. On two occasions exposures were made to the concentrated energy of the Victor lamp, 17 ampère carbon and iron contacts, directly over the fluid filled bursæ, with the hope that a more prompt absorption would be stimulated by the reaction upon the skin. From 8 to 9 exposures to the action of the light have been made, including the concentrated energy of the Victor lamp. The knee is smaller, there is diminished grating and absorption of part of the fluid. The patient can put her heel to the floor, does not limp so badly, the joint feels stronger and the circulation is improved. As yet the author notes only improvement in the syndrome, but expects, when treatment is reinstituted after the heat of the summer, with more frequent exposures, to modify the conditions to a much greater extent.

Recent Inflammations (Rheumatic) and Injuries to Joints.—In recent injuries to the smaller joints the author has obtained from a single exposure to the concentrated energy of the carbon arc (no inflammatory skin reaction excited) relief from pain, soreness and disability. A second and a third treatment has sufficed, this with the heat eliminated.

With the same mechanism a subacute rheumatic joint (metacarpo-phalangeal, thumb) several months' duration, swollen and painful, was relieved by a single exposure of

twenty minutes without elimination of the heat. The immediate relief from pain passed into a complete cure in a few days following treatment. Thus there are a host of ailments from which patients suffer, of no great magnitude nor moment, which can be readily relieved by the action of light energy. To the physician caring for graver pathologies they may not seem worthy of attention, but the author finds that every relief afforded from pain and disability in these minor conditions is a factor in the better being of the individual. In the larger joints, more extensively involved whether from injury—a sprain and contusion—or from a rheumatic inflammation the results should be equally good. It is only necessary to suitably adapt the means to the end.

Tubercular Ulcers.—Ravogli[1] reports a case of tubercular ulcer which yielded to the use of condensed light in a few weeks, from 15 minute exposures, twice a week.

The ulcerated area, the size of the palm of the hand, was situated on the dorsal region, just above the angle of the left scapula. It consisted of small ulcerated nodules, somewhat elevated above the level of the skin, coalescing together. The centers of the nodules were mostly ulcerated, showing a yellowish lardaceous bottom.

The exposure to the light stopped the itching and burning sensation. The entire surface became red and erythematous, the ulcers appeared as if painted with gelatin, the yellowish necrotic appearance disappeared, and in a short time they healed up, the small tubercles disappeared, a healthy cicatrix formed extending from the edges toward the center, the patient making a complete recovery.

Tubercular Glands.—These also lend themselves to the action of light energy. At the present writing the author has a case under care for which the concentrated energy of a 25 ampère iron cored carbon arc is being used. The sittings are three times weekly and from 30 to 45 minutes in

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[1]A. Ravogli, M.D.: Journal Cutaneous and Genito-Urinary Diseases, Jan., 1902.

duration. On one side of the neck a recent and deep cicatrix following the removal of a very large gland was apparent when she came under care. She suffered great pain all along the site of the scar and the parts were exquisitely sensitive. She also suffered severe neuralgic pains throughout the entire nerve distribution of that side of neck, face and head. The operation had left her with ptosis of one lid. There were several enlarged glands lying near the line of incision as well as on the opposite side of the neck. The case is improving both in so far as the enlargement and sensitiveness of the glands are concerned and in her general health. The severe neuralgic pains were relieved from the first, the cicatrix is softening and is less deep than at first. After two or three exposures, the wound opened up, showing that a fistulous tract had been left. This is evidently closed up as the discharge, sensitiveness and pain have disappeared. The ptosis is slightly improved with her general improvement.

Tuberculosis Pulmonalis. — Foveau de Courmelles[1] (Société de Biologie, Institut de France, December 24, 1900) found the chemical frequencies from an arc lamp of 12 ampères at 80 volts in which the thermal frequencies were filtered out by means of water, of value not only in the treatment of lupus vulgaris and lupus erythematosus as well as in various other dermatoses, but in pulmonary tuberculosis also. He used the chemical frequencies with a compressing lens of quartz. He seemed to regard the use of light in this condition as an entirely new observation. But light had been used in the treatment of pulmonary tuberculosis for some years, the author having employed all the radiant energies of the arc in the same class of cases since 1895. Courmelles reports a case of lupus with cutaneous and osseous lesions of twelve years' standing associated with cough and a slight *souffle* at the apex of the left lung, treated at the Hospital of Saint Louis by means of the chemical frequencies, as indicated above. After five sittings of 10 minutes each, the *souffle* had disappeared (September, 1901). Since then various tuberculosis patients had been treated, all experiencing an immediate sense of well-being followed by diminution in the cough and improvement in the stethoscopic signs. These results obtained from the use of cold light concentrated, localized, and used with a compressor, are the same as obtained by the author from the energies of the entire arc spectrum as well as its gaseous envelope and the ionization of the air. For there is every reason to believe that all these factors enter into a treatment by a diffused arc light in a comparatively limited space. Hopkins[1] reports two cases in detail with a similar result. He utilized a 50 ampère arc with a 20 inch condensing lens (a marine searchlight in fact), arranged so that the light could be concentrated on a surface an inch in diameter at a distance of 15 feet if desired. The application, however, consisted in focussing the light at a distance of 15 feet so as to secure a beam of from 15 to 20 inches in diameter. This beam was then directed to the chest of the nude patient, the exposure varying according to the tolerance of the patient from a half of an hour to an hour in duration. Ten cases in all had been treated with relief in every case from cough, temperature, expectoration and sweats within the first few days.

[1]Foveau de Courmelles, Standard. Abst. in Journal Phys. Therapeutics, Jan. 15, 1902.

The blue glass screen shown in Fig. 21 is used by Hopkins in order to sift out the heat. The method resolves itself, therefore, into the use of the concentrated visible chemical frequencies of the electric arc.

The experience gained in many of the skin conditions enumerated is, however, too limited to formulate any definite opinion as to the place of light energy in their therapeutics. Strebel and Barbensi have made use of light in furunculosis. Here the author would expect to secure good results. Leredde has treated rhinophyma and Strebel, Barbensi and G. J. Müller psoriasis. The author's experience

[1]Hopkins: The Phila. Medical Journal, Sept. 21, 1901.

with the latter condition has been given in Chapter IX. under Electric Arc Baths. Favus has been treated by Finsen and biskra-button by Petersen.[1]

Müller and others, according to Freund are authority for the statement that varicose ulcers, septic wounds, fistula after operation on bubo, etc., heal more quickly under the action of light energy. The author can corroborate this statement from clinical experience in some of the same and in similar pathological conditions.

Concentrated Electric Arc-Light Energy in Gynæcology.—Concentrated light has also been used as supplementary to the X ray treatment of very extensive pelvic epitheliomas, not as a curative agent but as a palliative one. By its use the pain and irritability attendant upon extensive inoperable pelvic epitheliomas, involving vaginal walls, cervix uteri, broad ligaments, rectum, bladder and, in some instances, the fundus uteri as well, has been relieved. Patients of this character have experienced much relief from pain, hemorrhage and ill-smelling discharge. All of which has meant a sense of well-being. In each instance it is the chemical action induced by, on the one hand, the rhythmic ultra-violet light energy, and on the other, the infrequent solitary pulse of X ray energy. From the very nature of the pathology it follows that a prolonged expenditure of the light or X ray energy is desirable. Thus far experience teaches us that prolonged applications of the X rays are to be avoided because of the danger of too extensive action upon the tissues. This is not true of light energy.

The patient is placed upon an operating table in the usual dorsal position for treatment. A glass speculum, funnel-shaped, at its proximal end, is then introduced. As glass does not permit the passage of the ultra-violet rays the lower vaginal walls are not exposed to this action but, on the other hand, the opening at the distal end secures the greatest expenditure of energy at the point of greatest pathological activity.

[1]Quoted by Freund.

The operating table is then wheeled sufficiently close to the arc light mechanism to permit the distal end of the funnel-shaped lid to project into the flare of the speculum, at a distance of from 6 to 8 inches from the introitus or in actual contact with the expanded rim of the speculum. It must be kept in mind that a mechanism is being used, the focus of which can be changed at will by the position of its carbons. The light is then turned on and the full force of the beam is projected directly into the vagina and against the exposed cervix uteri. An oblique position of the speculum brings into view the area of diseased tissue in the right fornix. A daily application, 20 minutes in length, is made, sometimes following the X ray and sometimes alone. There is neither pain nor discomfort, save from the prolonged dorsal decubitus upon the operating table. The whole vagina glows with violet light, but the full force of the chemical frequencies impinge upon the cervix uteri and vaginal vault, while less directly they must influence the broad ligaments.

In instituting treatment in this class of cases, light was used prior to the X ray and from single applications hemorrhage was controlled, odor markedly diminished, amount of discharge lessened and the character changed for the better.

Exposure of the entire abdomen to the beam of light 10 to 12 inches in diameter from the marine searchlight, has also been a source of great comfort to these patients mitigating all hemorrhage and distressing symptoms. It has, therefore, been used both intra-vaginally and to the abdominal walls as a palliative measure.

This same method is used by Hopkins[1] in the treatment of cases of pelvic cancer. He has utilized a Finsen tube, directing the beam of light at its focal point to the diseased cervix. His experience is corroborative of that of the author in the relief of pain, of hemorrhage, and creating a sense of well-being. He makes exposures of an hour or more.

[1]Brooklyn Medical Journal.

The Nature of the Changes Established by the Action of Concentrated Light Energy.—The macroscopical changes observed in the pathological condition in lupus, where the nodules are considerably elevated, i.e., hypertrophic, are these. When they have been sufficiently treated, the nodules and the raised edges of the lesions become flattened, and in the middle show a kind of necrotic appearance and then disappear. After two or three applications small nodules are scarcely recognizable, and where formerly confluent nodules formed continuous lupus infiltrations, isolated nodules appear with strips of healthy skin between them.

In ulcerated lupus areas the effect of the light treatment is to relieve after a 15 minute exposure, the troublesome subjective symptoms. Pain is abolished, itching if present ceases and there is experienced a sense of warmth and comfort in the part treated. This relief does not pass with the treatment but tends rather to an increased sense of well-being in the part for some time after exposure. Under the action of the light the surface of the lesion becomes shiny, as if it had been covered with a film of gelatin. They grow less both in surface extent and in depth and cicatrize. The redness of the skin gradually passes away, giving place to the normal coloring. The cosmetic effect as regards the appearance of the skin is all that can be desired, the new skin formed being soft and smooth like a baby's. The same is true of the scars. There is very little loss of substance and such as there is arises from the morbid process and in no sense is due to the treatment. The normal tissues are not affected by the treatment at all.

Finsen's treatment, beginning, as it properly does, at the periphery and taking in the healthy skin, has the effect at once of checking the spread of destructive lupus processes. The action of the light on lupus is not only an immediate but also a lasting one, going on even after the treatment is stopped. Suspicious spots have often been known to resume a healthy appearance following the suspension of treatment, even after several months. It was because of this fact that

Finsen concluded that the tubercle bacilli are killed by the light in a much shorter time than is required for the slow process of transforming the diseased reddish-brown tissues into healthy skin of a normal color.

The author does not believe that the curative action of light energy is due to its bactericidal action *per se*. The experiments of Bernard and Morgan, also those of Freund, prove very conclusively that light exerts no direct bactericidal action upon living tissues. In the treatment of curable cases of pulmonary tuberculosis with all the radiant energy of the arc, the bacilli gradually disappear from the sputum, not because they are killed, but first, because the physiologic resistance of the individual is increased by the action of light upon the blood, and second, the same oscillating swing of the corpuscles of the chemical frequencies of light energy, which in the one instance stimulates physiological processes, in the other serves to inhibit their action. The author is decidedly of the opinion as are Sophus Bang,[1] G. J. Müller, Glebowsky, Serapin, Sack and H. E. Schmidt[2] and Freund, that the action of the light in exciting tissue reaction is fundamental. Freund[3] believes that light acts as an irritant, penetrating, like the Roentgen rays, very deeply. According to him its action goes deeper than that of many chemical irritants, such as pyrogallic acid, resorcin and lactic acid, the effect of which is weakened by the albumen compound soon formed. The light irritant stimulates the granulation of tissue, which is usually but little inclined to change into connective tissue, to the formation of connective tissue and cicatrices. Probably the extraordinarily powerful illumination acts on the diseased tissues which are specially sensitive to light and less able to resist its action as a hyper-irritant, and thus, as is well known, kills the cells. By this means the morbid tissues are destroyed and prepared for absorption.

These histological changes are studied in detail in the following pages.

[1]VII. Congr. de Deutsch. Dermatolog. Gesellsch., Breslau, 1901.
[2]Berlin. klin. Wochenschr., 1901, No. 32.
[3]Freund, Radiotherapy.

Macroscopic Reactions.—When a patient has submitted to the action of light from a Finsen concentrator for an hour, the Victor lamp (original Lortet and Genoud), or some one of the many devices in use for from 15 to 20 minutes, there are no immediate modifications at the point treated. There follows upon the action of the light the development of an erythema at varying periods of time, depending upon the nature of the skin, and the richness in ultra-violet frequencies of the source of light, from a fraction of an hour to 4, 6, 8, perhaps 12-24 hours and sometimes even as late as two days after. The longer and the more profound the action of the chemical light energy, the later is the reaction in appearing.

Shortly after the appearance of the redness an œdema more or less marked appears. In the event of a thickened or hyper-pigmented skin having presented an obstacle to the penetration of the light energy or if the exposure has not been long enough the reaction stops there. Usually, however, at the same time as the œdema there appears a serous exudation which coagulates in more or less thick yellow crusts.

In a considerable number of patients this characteristic dermatitis goes on to the formation of true bulilæ, phylctenules, full of liquid, which likewise end in a crust. The time of their appearance varies according to the time in which the reaction establishes itself.

On an average eight days after exposure of a part to the light energy, all inflammatory reaction will have disappeared and the opportunity is offered for judging of the results which have been obtained.

Here again in this late reaction is shown the difference between the action of light and heat.

Chemical Light Reaction not a Destructive Process.—No matter if the séance be prolonged and with a powerful source of light energy, the Finsen concentrator with an 80-ampère arc used for two hours, for example, no loss of substance will be provoked. The same is true of other light

mechanisms. Just here it may be well to reiterate that the amount of penetration is in no sense dependent upon the production of an inflammatory action upon the skin. The concentrated complex of the energy of a carbon arc is capable of penetrating very deeply with a minimum of superficial inflammatory action; an iron arc, on the other hand, will produce an intense erythema, but penetrates scarcely at all.

If the séances are of unusual length, the reaction, as has been indicated, is slow in appearing and of longer duration. There may succeed an erosion to the phlyctenules, which, however, repairs itself in a few days.

Microscopic Reactions.—It will be recalled in this connection that it was not until the eighth day that important dermic reactions were observed by Leredde and Pautrier. There was observed at that time a state of increased hyaline tumefaction of the connective tissue. Some of the minute blood vessels were dilated, the endothelial cells of which presented some figures of karyokinesis. The connective tissue cells were equally tumefied, more prominent, and karyokinesis in places. Finally red blood cells were observed scattered outside the vessels, lymphocytes forming little masses in various places appearing to occupy the lymphatic spaces, and the mast cells were more numerous than normal. In a word it simply resolves itself into a condition of an acute inflammation. From this state of acute inflammation the consecutive process of repair and cicatrization is easily explained.

This then summarizes the histological reaction in the healthy tissue.

The Nature of the Regressive and Productive Tissue Changes Leading to Healing which takes Place in Lupus, Ulcus Rodens and Vascular Nævus under the Influence of Ultra-Violet Rays.—Sack, whose histological investigations were made upon Lupus, Ulcus Rodens and Nævus Vasculosus planus,[1] has shown that the first effect of light is upon

[1]Muenchener Med. Wochenschrift, July 8, 1902, A. Sack.

the blood vessels and that the first changes noted are swelling and proliferation of the endothelium. This is observed in its simplest form in uncomplicated angioma of the skin, and results in an endo-vasculitis with final obliteration of the vessels. There is nothing in the entire process related to burning or cauterization. In the latter, the reaction appears promptly, with the former later, and this fact negatives such a supposition. The clinical course of the process is also opposed to the condition produced by thermal frequencies. The absence of the coagulation necrosis, which accompanies every burning and cauterization, also precludes the possibility of any thermal influence. But even so, this is not needed as evidence, when the light is used in such a way as to obtain only the chemical activities or cold light. This then is conclusive, because not only the histological changes do not resemble those produced by burning, but there is an absence of thermal frequencies.

The histological changes established are very clearly shown in the complicated structure of a lupus nodule. The regressive changes are purely selective, in that they only affect certain elements, and these are the least resistant, of the diseased tissues, while the other elements both within and without the diseased focus are incited to increased activity. By the irritating influence of concentrated chemical frequencies, there are produced in the cells of the diseased skin such conditions as to make it possible for those not wholly diseased to recover and overcome the diseased ones. By reason of this action of the chemical frequencies of light visible and invisible, certain of the cell elements are absorbed (those of perverted or deficient vitality) while others become connective tissue cells, with the result of establishing actual healing. The process resembles a necrobiosis. Cells which are not hopelessly diseased undergo a retrogressive metamorphosis under the influence of the ultra-violet light, which seems to act as a physiological irritation. Histologically, blood vessels dilate, and an exudate is formed, mainly of leucocytes. Pigmentation follows from the exudation of

erythrocytes. The inflammation established by reason of the action of the light causes a successive and gradual regression of the disease. This is demonstrated by the diminished congestion and by the reabsorption of the infiltration. Glebowsky,[1] who has also made a careful histological study of the process of healing of lupus in the skin under the influence of light, reached the following conclusions: Twenty-four hours after irradiation by the chemical frequencies of light, pieces of the skin were removed. Upon examination, the vessels were found dilated and the surrounding tissues infiltrated with migrating leucocytes. In addition, the interstices of the connective tissue were somewhat wider, and slight vacuolization existed which was clearly marked in the giant cells.

In sections removed after 48 hours the same phenomena were much more marked and there was also fatty degeneration of the protoplasm and necrobiotic changes in the nuclei of the granuloma cells, especially in the giant cells (pyknosis and chromatolysis). Fig. 28[2] represents a giant cell from a case of lupus, two days after Finsen treatment, originally presented by Glebowsky to the German dermatological congress in which there is shown p. (pyknosis), v (vacuolized nuclei), k (fat).

After repeated sittings, the destructive appearances in the giant cells increase, and finally the cells disappear entirely. This, Glebowsky found, follows as a rule, after from four to five applications of ultra-violet light. The process of degeneration in the epithelioid elements was much less marked than in the granuloma elements. In them, Glebowsky and Serapin observed changes of a purely progressive character, for example, elongations of the nuclei and the cell bodies and elements of a spindle shape were met with, and these, in time, seemed to pass into fibres. During the acute

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[1]C. Serapin, Ueber die Veränderungen in Lupus granulom unter der Einwirkung des concentrirten Bogenlichtes, etc. VII. Congress d. Deutch. dermatolog. Gesellsch. Verhandlungs-bericht, p. 500 ff.

[2]Freund: Radiotherapy, p. 503.

reaction, the lymphoid elements of lupus showed rather pronounced fatty degeneration, and later on, oval and spindle-shaped cells were observed among them. Beginning with the upper layers of the corium, the cell elements in the granuloma disappeared more and more, as the reaction established by the treatment advanced and died away, the connective tissue becoming more and more conspicuous. This is shown in Fig. 29.[1] A lupus nodule after four sittings. (From Glebowsky-Serapin) (a) blood vessels with hyperplasia of the endothelium, (e) granulation elements between the epithelioid cells, (f) connective tissue. Only at the end of the treatment were the numerous blood vessels contained in the granuloma quite obliterated. According to Freund, there has not been obtained such a variety of effects in epithelioid elements from the use of the Roentgen ray, and in this fact he finds a point of difference between the treatment of lupus by the chemical frequencies of light and the Roentgen ray.

In addition to Glebowsky's and Sack's study of the histological changes taking place in lupic processes and those of the latter in Ulcus Rodens and vascular nævi the histological changes in lupus have also been studied by Leredde and Pautrier. The latter form an admirable study of the minute histological changes.

Biopsy on Tissue of a Lupus Patient after Several Treatments and Following upon a Quiescent Period of Fifteen Days.—Upon examination a white fibrous network between the meshes of which a violaceous tint persists without lupus tubercles, was observed. Under a low magnifying lens the epidermis formed a thick layer comprising 12-15 layers of Malpighian cells of normal size. They are regularly arranged and separated by some migratory cells. Under a high power magnifying lens the cellular spaces are a little enlarged and there is a little of the "etat-spongoïde of Unna" and here and there some cells which present the "etat-cavitaire of Leloir." A similar condition was observed in the

[1]Freund: Radiotherapy, p. 505.

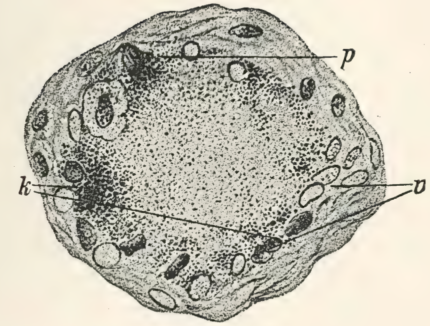

Fig. 28.

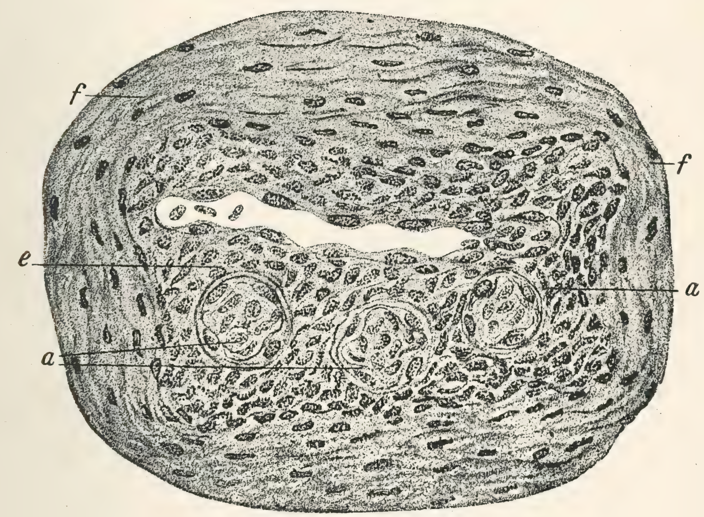

Fig. 29.

normal tissue. Papillæ exist only at rare points; in general a union of the dermis and epidermis is upon a line parallel to the cutaneous surface.

There is observed in the derma: (1) A universal sclerous transformation formed of connective tissue bundles slightly crowded; (2) vessels very much dilated and numerous, fewer where the sclerosis is more advanced and with very thin walls; (3) some few cellular nodules disposed in contact with the vessels and which are formed only in a lateral part of the preparation, while all the rest are formed of an almost homogeneous sclerous tissue.

Under the higher power a slight hyperkeratosis without parakeratosis is noted in the corneous layer. The granular layer is remarkable for its thickness. Upon the points of the projections there are found some small epidermic projections formed by collections of large cells covered with a thin corneous layer.

There are found between the Malpighian cells a number of cells of dermic origin with elongated nucleus of indeterminate cytologic variety. Some are distinguishable from mast cells with their characteristic granules. Very rarely eosinophiles are observed whose granules are scarcely distinct. There is observed in the mucous body, rete mucosum, the presence of figures of karyokinesis, a little more numerous than normally. They are not only found in the basal layer but a little above it as well.

At the level of the basal layer there are observed some very fine cells extremely flattened, which are stuffed with pigment and which evidently take their origin below the basal layer to the limit even of the derma, by a sort of a foot insinuated between the cells of this layer.

Pigment.—There are found globes of pigment isolated and intercellular. The Malpighian cells are themselves charged with pigment, under the form of fine ochre granules, numerous at the level of the superior pole of the cells.

The aspect of the derma varies according to whether it is the sclerous region with or without nodules. In the

sclerous region without cellular nodules, the tissue is formed of small connective tissue bundles, parallel with each other, slightly dense, separated by flat cells, very much elongated. There are found a great number of mast cells equally flattened; exceptionally one or two round cells, with nucleus of connective type, leaning against the wall of the vessels.

In the nodular region, the most important of them are formed of cells with rounded nuclei, without important protoplasm, having the characteristics of lymphocytes; at the limit some mast cells can be found. Other nodules, perivascular, are formed by very large plasma cells of typical character.

There also exists generally in this region extremely numerous and large mast cells, always isolated and of various forms, globular and drawn out.

At some points there are found masses of large colored nuclei, with diffuse chromatin, presenting the characters of fixed yellow cells, a large number of which are found in different stages of karyokinesis. These nuclei are found mingled with plasma cells, and it seems as if the transformation of the lupic nodules was assisted by hypergenesis of the fixed cells.

The Process of Cicatrization.—This is in substance a fibro-sclerotic transformation of the skin, occurring in an extremely regular manner, without epidermic atrophy and without important dermic atrophy.

This transformation is established by formation of young connective tissue in the regions evacuated by the lupus. The presence of more numerous vessels in the region of the lupic nodules than in others corresponds to the progressive devascularization of the tissue which characterized it clinically.

In the regularity and thickness of the epidermic layers is to be found the explanation of the regularity of the cicatrices.

The thickness, despite the pigmentation of the deep layers of the epidermis, assures the relative whiteness, so characteristic of the condition of the skin subjected to the action of light energy.

Nature of the Liquid which Forms the Phlyctenule.—In common with all organic liquids this presents an alkaline reaction. Its cellular formula shows a very great richness in eosinophiles, as is evidenced by the proportions in the following table:

Eosinophiles	56.1 per 100
Polynuclears	14.8 per 100
Mononuclears	7.4 per 100
Red globules	21.7 per 100

Upon examination of the plates all the cellular elements appeared upon a foundation formed by the uniformly orange-colored liquid, which was like a true lacquer. This liquid is very rich in fibrin and it is this which, in the light reaction, gives rise to the yellow crusts which form from the phlyctenules.

In this very complete histological study of the minute changes which take place in a lupous process, in connection with those of Sack and Glebowsky, there is afforded incontrovertible evidence of the nature of the changes established which serve to fix most firmly the foundation for the science of light energy in all skin pathologies.

CHAPTER XIII.

The Concentrated Energy of Incandescent Light Spectra, Mechanisms, Methods of Use and Therapeutic Indications, Local Incandescent Baths, Rheumatic Joints, Chronic Synovitis, etc. Incandescent Light in Gynæcology.

The Concentrated Energy of Incandescent Light Energy.

In the many uses of light energy from the various sources of light, there exist always the need (1) for an application of the energy when diffused into considerable space, as in a bath, or (2) in concentrating that energy either within or upon a part.

One of the most important uses of the concentrated energy of an incandescent lamp is that known by the name of Minim; but as it does not include the entire energy, only that of the visible chemical frequencies or blue light, it is considered under the frequencies of the blue region, rather than here. In this connection it is necessary to refer to (1) the use of the energy of the incandescent light spectra from one or a group of lamps upon a part, as, for example, in the treatment of a rheumatic joint, and (2) the use of miniature lamps within accessible mucous cavities, the vagina, rectum, bladder, nose and in the ear.

The spectrum of the incandescent light is deficient, as has been stated, in the more chemically active frequencies. It bears no comparison to that of the sun nor of the electric arc. Both are much richer in the blue, indigo and violet than the incandescent, and the electric arc by its exceeding richness in both blue-violet and ultra-violet far surpasses the incan-

descent lamp as a source of light energy of intense chemical activity. The sun is also much richer than either in the blue violet, but feeble as the incandescent lamp is in chemical energy, it is still capable when skilfully used of much good. The luminous efficiency of an incandescent lamp is but about one-third that of the electric arc, while poor in blue, indigo and violet frequencies it is rich in green, yellow and red frequencies. Because of the glass-enclosing bulb such ultra-violet frequencies above 30 micro-centimetres in length as this source of light may generate are of no therapeutic value.

Both the chemical and the luminous efficiency may be increased by increasing the current. Therefore where the most intense effect is desired from the concentrated energy of one or more incandescent lamps, the higher candle-power should be used. For example, a 32 candle-power will give out more of the valuable blue-violet frequencies than a 16; while a 50 candle-power will produce a still more powerful effect. The degree of energy should bear a relation to the abnormal condition for which it is used.

Mechanisms for the Use of the Concentrated Energy of the Incandescent Light Spectrum in the Treatment of Joints, Etc.—For this purpose a partial bath of incandescent light is used. The arrangement of the particular mechanism depends upon the anatomical locality to be treated.

A simple arrangement of a hoop in the concavity of which are placed a few incandescent lamps of varying candle-power, from a 16 to a 50, according to the degree of light intensity desired, may be improvised, where the more complete and elaborate equipment is wanting. This can be placed over the affected joint, as the knee, and a blanket thrown over it. In this way the indications for a local radiant energy bath to a rheumatic joint can be adequately met at a patient's house or for that matter in the physician's office.

The small boxes of suitable size and shape provided with reflecting surfaces and with the incandescent lamps fixed to the side and with suitable openings for the insertion of a

limb, or a group of lamps provided with reflector are to be preferred, however.

The device of Hedley referred to in the chapter devoted to incandescent light baths comes under this head. This device consisted of incandescent lamps each carrying 2.5 ampères of current fixed in reflectors.

A single lamp may be placed in the centre of a reflecting cone for the treatment of a hand or a foot for example. A similar arrangement may also be used for a strictly localized spinal application or to any part of the body where a strict localization is desired.

The thermal effect, and for that matter the chemical as well, may be regulated by (1) the distance of the lamp from the part (2) by the number of lamps and (3) by the regulating device or rheostat.

Freund uses two incandescent lamps of 100 normal candle-power, each with its own cut-out switch, which are fixed in a parabolic metal reflector. The conducting wires of these different arrangements of incandescent light mechanisms for radiant energy baths, whether local or general, may be carried to a rheostat by means of which the current may be carefully graduated and the lamps made to glow more or less brightly according to the light intensity desired. In using concentrated incandescent light energy, it is better to thus control the intensity of the light of the group rather than to do so by cutting out one or more lamps. In Freund's apparatus the reflector on its open side has colored glass filters or fluids. This apparatus may be fixed to a stand.

For the extremities there are used drum-shaped boxes (see Fig. 30) into which groups of lamps, 2, 4, 6, 8 or more, according to the size of the part, the condition, and the degree of light intensity necessary, are placed. In these an opening may be cut in the thickest part of the casing, the exact size of the reflector, into which it can then be fitted. In minor points the construction of these mechanisms is different but the essential principle is the same in all. The

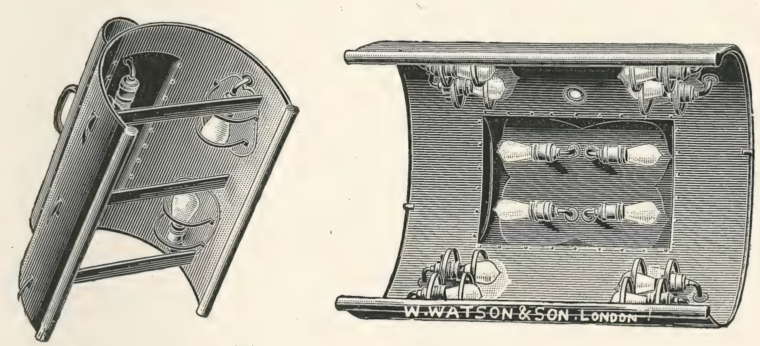

Fig. 30.—Local Light Baths.

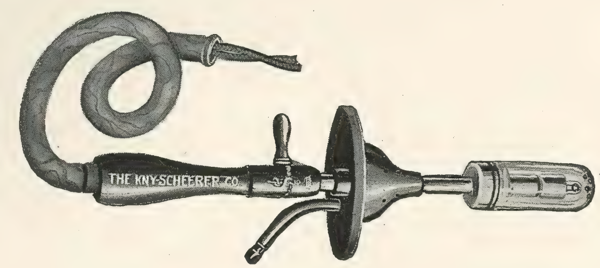

Fig. 31.

drum is placed on two supports and fixed with straps. In this position it can be turned so that the light energy may be distributed upon all parts of the extremity to be treated. A netting of asbestos may be stretched inside the drum at some distance from the reflector to prevent the exposed limb from coming too near the lamps.

An encasing framework covered with heat-retaining material is also constructed for the treatment of the trunk. It is an incomplete cylinder and may be termed trough-shaped. There is a rectangular opening at the top into which the reflector is placed and the two open ends are closed by curtains of the same material as the cover. Below the opening into which the reflector is placed but attached to the rollers on the outside of the wooden frame is a thick close curtain of asbestos, consisting of two nets, one coarse and the other fine-meshed, superimposed the one over the other. Then by drawing the one or the other part of the curtain by means of the rollers the strength of the light energy may be varied. Such an apparatus may be used without a reflector, although by its presence there is an intensification of the radiant energy.

These as well as all apparatus for the administration of general or local light baths should be fitted with thermometers.

A very desirable local bath of incandescent lamps can be readily arranged for an application of the light energy to the spine. For this purpose a rectangular box the length of the cord or spine as well, into which from 8 to 10 lamps are placed, the sockets alternating on the sides of the box, is permanently adjusted to the wall. An adjustable stool is placed just under and a little to the front of this mechanism upon which the patient is seated. The sides and ends of the rectangular box-like frame approximate closely enough the surface of the back to secure a strict concentration of the light energy. The interior of the enclosing frame should be finished with white enamel carefully put on, or mirrors in order to obtain a good reflecting surface.

These local baths are more flexible than the general bath, as they may be carried to the bedside of the bed-ridden patient, or they may be simply and inexpensively constructed for the more permanent use at the home of chronic invalids unable to come to the physician's office for treatment. Their use should, however, be always directed and supervised by the physician himself.

Temperature of Local Baths. —Applications of concentrated incandescent light energy can be made at a higher temperature than the general bath, which is often desirable. A general bath becomes unpleasant when the temperature reaches 122°F., but in the administration of concentrated incandescent light energy as high a temperature as 212°F. can be readily borne, especially at the second or third exposure. From this concentration of the light upon a part, perspiration is not produced save at high temperatures, from 194°F. to 221°F., but is generally very profuse. It will be recalled that in the general bath perspiration has resulted from a temperature of 85°F.

Physiological Action.—The physiological action of concentrated incandescent light energy is the same as that of the general. There is always produced by one exposure of the extremities a rise in temperature of the whole body as well as in the part treated. Freund reports that he has observed that after an exposure of from 30 to 45 minutes, when the temperature of the enclosing apparatus was about 176°F., that patients reported themselves getting comfortably warm over the entire body. The face coincidently becomes a little flushed and the temperature upon being carefully retaken showed a rise of from 3° to 10°F. The pulse, on the other hand, showed as a rule no change, seldom being even slightly accelerated. The respiration too was unaltered.

There is also a rise in local temperature. This increase in temperature may be explained in different ways: (1) The heating of the body by the direct transmission of heat from the apparatus into the tissues, (2) by the increased effect of the local temperature of the blood upon the entire blood stream, (3) by a sympathetic rise in temperature through the nervous system.

The author agrees with Freund, who offers the above explanation that the first explanation may unquestionably be disregarded; the second and third conditions are both active, perhaps equally so. There must, however, be a decided temperature effect from the increased temperature of the blood, and as it is constantly in motion, this effect must be carried to every part of the body.

Effect on Skin Temperature.—This reaction from the effects of light and heat rays upon the skin temperature has recently been studied by Sommer[1] who used in his experiments the thermopalpation apparatus of Herz. He found that when no acute exacerbation of the process existed, the temperature of the skin over a chronically diseased joint was lower than that of the same joint of the opposite side. The action of heat and light rays always caused the temperature of the involved joint to rise higher than that of the normal side; however, cases occur in which the temperature under the influence of the rays is subnormal on both sides.

The light and heat rays do not cause a cooling reaction as follows cold and warm applications. Short applications of the rays cause an immediate rise of temperature which remains longer than if the application has been of longer application. After from 2 to 4 hours the relation between the two sides is reversed, i.e., the side exposed to the rays seems colder than the other, a condition brought about by the reaction of the unexposed side.

Therapeutic Indications.—The indications for the concentrated incandescent light energy is by no means confined to joints, but is indicated in injuries, sprains, contusions, ecchymoses, superficial inflammations and suppurations. The latter are extensively considered under the visible chemical frequencies of incandescent light energy or blue light as used more exclusively by Minim and Kaiser.

[1] E. Sommer, Berliner klinische Wochenschrift, Oct. 5, 1903.

seated processes at first daily, then every other day, twice a week and less often as the case progresses.

Both Chemical and Thermal Energy are Active in Concentrated Incandescent Light Energy.—While the chemically active energy of incandescent light spectra is small, still it exists, and there is, therefore, an effect from such penetrant blue-violet frequencies as are present. This is slight as compared with the effect of the thermally active energy as well as the luminous frequencies. The longer waves are fairly abundant and they possess the power of penetrating the deeper layers of the skin. The exact nature of their mode of action is as yet conjectural. It is known that high temperature has a beneficial effect upon ulcerating processes. The irritation of the penetrating long-waved frequencies may stimulate healing and the formation of connective and scar tissues in the same manner as chemical irritants do when applied to sluggish ulcers for the purpose of stimulating granulation tissue formation.

Concentrated Energy of Incandescent Light Spectra in the Treatment of Inflammations of the Mucous Membranes. —The principles involved in the application of light to the treatment of inflammations of the mucous membranes are the same as in any other tissue, skin or glandular, for example. It is simply a matter of utilizing, to the fullest extent possible, the chemical frequencies of light, to overcome the blood stasis, swelling, exudate, pain and impaired function characteristic of the special disease.

Light is applicable to the catarrhal and specific inflammations of the throat, nose and ear, to the inflammations catarrhal, and specific of the pelvic organs, in fact to any mucous membrane to which it can be applied.

By the action of the chemical frequencies of light, both the visible and invisible, tissue reaction is established, with the result of promoting normal circulatory conditions, thereby relieving the blood stasis and of promoting the nutritive activity of cell life. As there is a stimulation of the skin reflexes, when the agent is applied to the skin, so with

mucous membrane contacts a stimulation likewise of their reflexes must result, for the action of the light, as has been shown, is a vigorous irritant to the nervous system.

Both the visible and the invisible chemical frequencies can be used in the treatment of inflammation of the mucous membranes, and the applications may be made locally and also to the entire organism. The use of the invisible chemical frequencies from electric arcs and from spark light is considered in their appropriate place. The visible chemical frequencies can be utilized by means of a diagnostic incandescent lamp of white glass or enclosed in a blue glass bulb, of the highest candle-power permissible for the size of the bulb, which can be carried directly into the nares, the mouth or the ear. Such a lamp can be applied directly to the tonsil itself, it may be attached to the laryngoscopic mirror, and the light directed to the inflamed larynx with beneficial result.

The arc light can also be used in treating the nasal, aural and buccal cavities. With it a profounder influence is obtained, involving greater tissue reaction when topically applied, by reason of the complex chemical frequencies, the invisible as well as the visible. For this purpose, the marine searchlight, as described in the previous chapter with the funnel-shaped attachment, can be adjusted so as to throw the beam of light at its focus, up the nares, in the vagina, or into the mouth and down the throat, the mucous membranes of which have first been rendered anæmic by painting with adrenalin.

In this connection the reader is referred to Pietnikoff's observations considered under the visible chemical frequencies of blue light, and also to the use of the concentrated energy of electric arc spectra in malignant disease of the pelvis discussed in the previous chapter. The use of these means has become one of routine practice with the author and all mucous membrane troubles in patients under care are (1) subjected to the action of light energy in suitable form or (2) to an exhibition of electrical energy either sup-

plementary or alone according to the indication. This is incidental to the general treatment, as the need for the best nutrition and function of the entire organism is after all paramount.

A Water-Cooled Lamp for Gynæcological Work.—The interest in light therapy and the good results obtained from its use in relieving pain and stimulating absorption in a variety of chronic skin conditions, as well as in localized septic conditions, such as blood poisoning from insect bite and inflammation of the labia majoræ prior to pus formation, suggested to the author the desirability of utilizing a water-cooled vaginal lamp in the treatment of chronic diseases of the uterus and appendages.

The lamp shown in Fig. 31 was devised by the writer ten years since for the purpose of demonstrating the possibilities of transillumination of the pelvic tissues and was presented to the American Electro-Therapeutic Association at its fourth annual meeting in 1894.[1] In transilluminating the pelvic tissues it was found that wherever there was morbid material, either in the form of exudative matter pustules or abnormal growths, as fibroid tumors, sarcoma, etc., the tissues were not transillumined but remained absolutely black. In the absence of these pathological states, the tissues were transillumined to within two inches of the umbilicus, but nothing was demonstrated other than as above save the course of the blood vessels.

From the experimental work done at that time, the writer was convinced that transillumination of the pelvis was of doubtful utility as an aid to diagnosis, and the lamp was for a time laid aside. Within the past two years it has been taken up, however, and used therapeutically in the author's gynæcological practice. It is a very practical and efficient means of exposing the pelvic organs directly to the influence of incandescent light energy.

The instrument consists of a hard rubber device (it could

[1]Transactions, American Electrotherapeutic Association, 1894.

be of blown glass) constructed upon the same principle as the electrode used for vaginal hydro-electric applications. It is provided with an inflow and outflow for the circulating water and also an obturator to close the introitus. The vaginal tube, instead of being fitted with a perforated hard rubber bulb at its distal end, as in the electrode, is provided with a metal socket into which the lamp bulb is fitted, and to which the electric light wires are carried. The handle serves not only for holding the instrument in position but to transmit the wires to the lamp socket. A metal collar with screw threads surrounds the vaginal tube just below the lamp socket. Over the lamp bulb is placed a glass tube, one inch in diameter and $2\frac{1}{2}$ inches long, perforated at its distal extremity to permit a continuous flow of water around the lamp bulb and into the vagina. At its proximal end, inside is sealed a metal ring. By means of this it is securely screwed into the metal collar on the vaginal tube, making an absolutely water-tight joint.

The lamp now in use requires 32 volts and 8 ampères, giving 8 candle-power. Lamps of less and greater candle-power can be used, and the author has used lamps of even 20 candle-power.

The construction of the instrument is such that it can be rendered absolutely aseptic by immersion in suitable antiseptic solutions.

The lamps are constructed for both a 110-volt direct-current and a 104-volt alternating-current circuit, and can be used with a suitable shunt resistance, or by a series lamp resistance.

The lamp is provided with a very complete shunt resistance by the manufacturers which the author prefers to the series lamp resistance.

With the lamp described all the radiant energy of an incandescent light passing through glass can be utilized. The intense thermal effect is practically eliminated by the passage of water, which is kept not higher than body temperature and often even lower, if no contra-indication exists. There can

be no effect from frequencies above 30 microcentimetres if generated, because of the glass enclosing the lamp filament as well as the glass of the water-cooling tube. The therapeutic value of the frequencies which are permitted to pass, independent of the lower and higher frequencies, which are eliminated in the one instance by the water and in the other by the glass, is practically that of the visible chemical spectrum of incandescent light from which the more intense thermal energy has been eliminated. Recently the author has been provided with lamps for this apparatus, termed cold lamps. They are not strictly cold, but can be used for some moments without water cooling. Care must be taken not to permit too vigorous an inflow of the water. No matter how well constructed there is always the possibility in a water-cooled lamp of a penetration of water into the lamp socket where contact is made.

From the use of this concentrated light energy there was established in four weeks' time in a case of par-ovarian cyst marked relief from the pain and soreness and a diminution of fully one-half in the size of the growth. This diminution was evidently due to the absorption of the fluid contents of the cyst.

A fountain syringe or an irrigating jar is connected with the inflow, while the water drains into a rubber douche pan, placed under the patient into a basin at the foot of the operating table. The minimum of inflow is sufficient to keep the lamp cool. Applications are made daily at first, subsequently three times a week and later less frequently, and from 15 to 20 minutes at a sitting.

It is the writer's belief, based upon clinical experience, that light locally applied has a wide field of usefulness in gynæcological practice.

Photospeculum, an Appliance for Light Energy in Gynæcology.—Makawejew[1] has invented an appliance which is a combination of a vaginal tubular speculum with an in-

[1]Russki Vratch, May 3, 1903.

candescent electric lamp that can be used for transmitting the effect of light upon the internal genitals in women. Very good results according to the author have been obtained by the use of light, especially in the treatment of chronic diseases of the uterus and appendages accompanied by neuralgic pains. Applications may be made through the abdomen by means of the ordinary incandescent lamp with a suitable reflector, as electric light does not affect the surface of the body alone, but penetrates into the deeper tissues. Two types of apparatus have been devised by the author in which small lamps can be introduced into the vagina. Their size is such that they do not give off an undue amount of heat.[1]

The first apparatus consists of the ordinary glass speculum, into the distal end of which is inserted a stopper fitting into its lumen, which bears the stem of a small lamp through which the two wires supplying the current are passed. The second appliance consists of two glass tubes shaped like test tubes, one within the other and provided with a metallic collar uniting their open ends. The electrodes leading to the lamp within the inner tube pass through the centre of this collar.

The space between the glass tubes is connected with inflow and outflow tubes, so that a continuous current of water may be maintained around the lamp. The flow of water is maintained at body temperature during applications of from 5 to 20 minutes.

It is believed by Curatulo[2] that dilatation of the capillaries, the direct stimulation of the cells, and the reflex excitement produced in the vaso-motor nerves by the application of light baths will certainly benefit some forms of pelvic diseases.

Curatulo has devised a speculum with which he tests the efficacy of light baths in diseases of women. By means of it the incandescent light energy is divided into its constituent

[1]All of these miniature lamps give off considerable heat. The Author.
[2]British Medical Journal, Oct. 11, 1902.

parts. The three kinds of energy, heat, light, and chemical, are isolated and applied separately, or united according to the case. His device also permits the simultaneous use of the liquid douche and the light bath, or the latter may replace the former and act as a hot-air douche.

In cases of metritis, or hypertrophy of the cervix, he believes that an important modification of nutrition may be obtained by moderate application of the chemical rays. In imperfect development of the uterus and the cervix (a frequent cause of sterility), the ability of the chemical rays to improve nutrition should be useful. In perimetritis and para-metritis, conditions which frequently cause uterine displacements, an application of the chemical rays tends to facilitate the absorption of exudations. In uterine inertia the vaginal light bath is useful by reason of its stimulating effect. Curatulo is of the opinion that the germicidal power of the chemical rays will be of value in specific ulcerations of the cervix.

As yet but comparatively little has been done in gynæcological practice, but the vagina and adjacent structures lend themselves to the application of light energy better than other accessible mucous cavities.

Dr. A. I. Orloff,[1] however, seems to have investigated this subject very thoroughly. In a preliminary communication he gives the results obtained in a series of inflammatory conditions of the pelvic tissues from the use of white light. This work begun in November, 1901, covered 50 observations, 38 out-patients and 12 hospital patients. Lamps of from 5 to 16 candle-power were used. The minimum expenditure of energy was made in the beginning of his work, the higher candle-power being used subsequently. Orloff used the apparatus of Makawejew described on a previous page. Orloff's conclusions may be summarized as follows: (1) Light energy is indicated in a considerable number of inflammatory diseases of the uterus and adnexa, such as metritis, parametritis, perimetritis, salpingitis and oophoritis, both in their chronic and especially in their acute forms. (2) The chief and most pronounced action of the light is seen in the amelioration or entire cessation of pain. (3) Under the influence of light exudates and accumulations of pus diminish or disappear entirely. (4) The pain during menstruation (dysmenorrhœa), especially of a spasmodic character, becomes considerably diminished. (5) The pain accompanying posterior flexions of the uterus and nervous affections of the ovaries (neuralgia) is markedly diminished, and after the first application of the treatment it may be possible to restore the uterus to the normal position without any pain. (6) Apparently, erosions of the cervix also yield to this treatment. (7) The amount of leucorrhœa in the uterine cavity and cervix becomes lessened, especially in affections of gonorrhœal origin. (8) Menstruation as well as uterine hemorrhage contra-indicate the application of light. (9) Pregnancy should also serve as a contra-indication in view of our lack of knowledge as to the action of light on that condition. (10) No opportunity was afforded to employ the treatment in cases of tumors. (11) As untoward effects of the treatment may be mentioned the appearance in some patients, after 3 to 4 applications, of general malaise and a feeling of numbness in the extremities, this condition disappearing in 2 to 3 days. (12) The number of treatments required before any improvement in the patient's condition is noticed depends upon the character and the stage of the disease. In Orloff's experience it varied from 8 to 40, each treatment consuming 10 to 20 minutes, repeated daily or every other day. No other form of treatment was employed. The author can corroborate the conclusions of Orloff from a personal experience in the use of light energy in the conditions enumerated.

In view of the fact that Hammer observed experimentally that the movements of the fœtus in utero were excited by the action of light, the condition of pregnancy should be regarded as a contra-indication or at least as one in which

[1] Russki, Vratch, Jan. 4, 1903. Phil. Med. Journ., April, 1903.

every precaution should be taken. Still, as the continuous current when not interrupted has no untoward action upon the pregnant uterus the author questions whether the chemical action of incandescent light energy would have any untoward effect.

From an exposure of all the pelvic tissues rich in blood supply to the penetrant chemical frequencies of the incandescent light spectrum, a considerable absorption of the light energy must follow. During a 10, 15 or 20 minute exposure, the blood passes and repasses the vaginal tissues until finally the entire blood stream has received its quota of energy. This means increased oxygenating power and the effect is not only local but general. There has been in the author's experience almost an invariable sense of well-being and refreshment following the use of vaginal applications of light. In several instances a sense of general malaise and a feeling of numbness in the extremities has been experienced which has disappeared as noted by Orloff. This has been regarded by the author as an indication that the expenditure of light energy has been (1) too great or (2) continued over too prolonged periods of time. Gautier and Thomson of Odessa,[1] are quoted as having used incandescent light energy in uterine fibromas, para and peri metritis, metritis and thrombic endometritis favorably affecting the symptoms but without any brilliant results.

Sensitization of the Pelvic Tissues.—A more profound and deeper seated action should follow upon the use of suitable sensitizers by painting the mucous membrane with a solution of the same and then applying incandescent light energy. By the preponderance of yellow in incandescent light spectra sensitizers capable of accentuating the action of the yellow frequencies (if such exist as would be applicable), should prove of value. The electric arc light energy carbon or iron or the light of a spark condenser lamp are to be preferred for this purpose, for there are a considerable number of

[1]Treatise on Radiotherapy and Phototherapy, edited by Bailliere.

sensitizers upon which the visible and invisible chemical frequencies of light act.

Light Energy in the Treatment of Ozœna.—Dr. Ignazio Dionisio[1] in the experimental treatment of ozœna with light projected it directly, by the aid of reflectors, into the nasal fossæ through the nares, dilated for this end. Both arc light energy and that of incandescent light was used. Sometimes with the former the light was concentrated upon tubes of crystal, introduced into the very fossæ themselves. He has also used little electric lamps, in a bulb and with a circulation of water, introduced directly into the nasal fossæ, or larger lamps, applied in the oral cavity similar to those used to obtain an illumination by transparency of the bones and nasal cavities.

In six cases where the treatment was made regularly, M. Dionisio has observed a remarkable diminution of the crusty secretion and the fœtid odor characteristic of ozœna. He does not feel certain as to the permanence of the results.

Light Energy in Otitis Media Purulenta Chronica.—Subsequently Dionisio,[2] following the excellent results which he obtained in more than twenty cases of ozœna, treated by means of light, applied this method in cases of otitis media suppurativa chronica. To this end he employed intense luminous radiations, which he caused to pass through the external auditory canal, into which he had introduced a speculum fixed by a bandage to the head of the patient. In ten cases of otitis media suppurativa fœtida in which he ordinarily used, as had been his custom for from 10 to 20 years, detersive lavage, removal of polypi, antiseptic medications, and cauterizations he applied only the energy of the luminous radiations, following which he had the satisfaction of establishing the cure of four of his patients, after a variable number of from 20 to 40 séances of two hours each.

[1]By Dr. Ignazio Dionisio. Rev. Internat. d'Élec., Jan., 1904. Gazzetta Medica Italiana. Nov. 6, 1902.
[2]Dr. Ignazio Dionisio. Rev. Internat. d'Élec., Jan., 1904. (Extract from communication made at the 11th section of the 14th Internat. Med. Congress at Madrid, 1903.)

In his other patients there was a very notable diminution of purulent secretions.

Dionisio believes that the curative virtue of the light should be attributed to its antibacteriological power and perhaps also to its exciting action upon the nutrition of the tissues.

The fundamental action is, the author believes, the exciting action upon nutrition. It must not be lost sight of that the bactericidal action of light takes place without, not within living tissue.

Prostatic Hypertrophy.—Gautier[1] reports using the concentrated frequencies of the red region from a lamp of 2 ampères at 110 volts directing the light upon the perineum and inferior abdominal region. He found that this energy exercised a beneficent action upon the hypertrophy of the prostate and the retention of urine. For the relief of the painful symptoms Gautier employed the visible chemical frequencies, only using the same degree of light energy but with a blue glass enclosing bulb. This double benefit, i.e., diminution of the retention of the urine and relief of the spasmodic pains, added to the improvement of the patient's general condition, is usually obtained from the fourth to the eighth sitting. Gautier sums up the method for the cure of hypertrophy of the prostate, as follows: (1) Augmentation of the vesical contraction; (2) rapid disinfection of the bladder as by a septic treatment; (3) micturition less frequent and more abundant; (4) amendment of the pains of micturition.

He regarded the treatment in young patients as worthy of attention, capable of hindering the evolution of prostatitis; with old patients it is to be regarded as a palliative method only, but is of unquestionable value where there does not exist near or distant infection.

[1]Revue Internationale d'Électrothérapie.

CHAPTER XIV.

The Exclusion of All but the Frequencies of the Blue Region of the Spectrum, or the Visible Chemical Frequencies. Blue Light as by the Method of Kaiser and Minim; Its Therapeutic Indications. Contusions, Sprains, Open Wounds and Tuberculosis of Joints.

Blue Light Energy.

It is easily possible to utilize the visible chemical frequencies of the spectrum, by the use of screens of blue glass. The glass effectually prevents the passage of any of the frequencies of the ultra-violet region, i.e., less than 30 microcentimetres, and at the same time effectually shields from the frequencies below the blue or the yellow green and red frequencies. The thermal effect is minimized by the blue glass screens, and can still further be excluded by the use of an interposed solution of sulphate of copper. By the exclusion of all but the visible chemical frequencies, blue, indigo, and violet, Kaiser[1] who had observed the favorable action of light on a septic ulcer carried out further experiments, and found that (1) tubercle bacilli in pure cultures were killed in 30 minutes by a powerful blue light arc at a distance of 5 metres, whilst they survived the radiation of an ordinary arc; (2) tubercle bacilli placed on a patient's back, blue light being at the same time directed to the chest at 5 metres for 30 minutes and the procedure repeated in six days, became weakened; (3) pure cultures of tubercle bacilli were killed when exposed to the radiation of an arc concentrated through a hollow lens, containing a solution of alum and methylene blue with ammonia. (4) When the spectrum was

[1]British Medical Journal.

split up, cultures lived in red and yellow but were killed from the blue violet to the ultra-violet. (5) Photographic plates attached to patient's back (light being excluded), and the radiation sent through the patient's body, a blurred positive was obtained. Subsequently to these experiments Kaiser treated two cases of advanced phthisis with the same blue light, after six days night sweats ceased and cough became less; at the end of six weeks there was continued diminution in the number of bacilli. In tuberculous abscesses of the thigh healing was obtained in four weeks. In a tuberculous child with weeping eczema cure was established in five weeks. Therefore, in view of the foregoing experiments, Kaiser thinks that blue light kills tubercle bacilli; that chemical rays can pierce the body sufficiently strongly; that blue light acts powerfully as a resolving agent and also as a local sedative; that with a sufficient concentration it may even produce anæsthesia.

In a comparatively recent article from the pen of this observer[1] there is the following detailed account of his experiment to prove the penetration of the visible chemical frequencies and those bordering on the ultra-violet of greater length than 30 microcentimetres, even though these are largely absorbed in passing through the tissues: A medium-sized man was placed in a dark room, and a photographic negative was placed on his back. Over this negative was placed a prepared positive film, the whole being fastened on with plaster. A beam of blue light was then thrown on the thorax (approximately on the front of the thorax notes the translator). A longer or shorter time was required to blacken the film, according as the thorax of the patient was large or small. Then a film only was pasted on, there was produced, after 25 minutes or so, a picture resembling a Roentgen positive, since the blue and violet frequencies penetrate the bones, which have not a rich blood supply, better than other blood rich tissue.

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[1]Wiener klinische Rundschau, April 19 and 26, 1903. Abs. for Med. Electrology and Radiology, July, 1904.

The arrangement of the mechanisms used by Kaiser in his work cannot fail to be of interest and assistance to the reader. First, he notes that the blue glass of the screen must be carefully tested since most of the blue glass in every day use is unfit for therapeutic use, as it permits the passage of all the frequencies of the spectrum. Kaiser uses a 15 to 30 ampère electric arc light, the carbons of which are arranged horizontally and provided with the usual automatic mechanism. The mechanism, practically much the same as a marine searchlight mechanism, is enclosed in a cylinder, freely movable in all directions, at the back of which a reflector is placed, the end of the cylinder toward the patient being open. Between the light mechanism and the patient stands the blue glass screen for filtering the dispersed light. This is made of strips of blue glass and is practically the same as shown in a preceding chapter. The frame is placed somewhat obliquely to prevent light going through the fissures formed by the strips of blue glass and for the same reason other apertures in the apparatus are filled in with black cloth.

The patient is placed beyond the screen, which can be set higher or lower as required and the beam of light is directed through the glass on to the exposed diseased area for half an hour. In the treatment of deep-seated lesions two concave glasses containing a solution of alum to absorb the thermal energy are placed within the screen in the place of the strips of glass and the diseased structure is brought into the focus of this lens.

Where the lesions are still more deeply seated and a profounder effect is desired a concave lens is utilized in the cone of light coming from the lens, thereby producing a more or less concentrated parallel beam of light with consequent shortening of the time required for treatment. Any slight heat felt by the patient is probably due to the yellow frequencies which have not been absorbed by the alum solution. This solution is constantly changed by a special apparatus.

The reflector is placed at just such a distance from the glass strip or lens that it will not crack with the heat. With

a continuous-current 20-ampère arc, this distance is estimated at about 2 metres, while with an alternating current the distance is but three-quarter metre.

Colored spectacles are worn by patients during the exposure to the light energy. Tuberculous diseases of the skin, joints and bones heal with a beautiful white scar. After from 14 to 20 exposures of half an hour each, the exposed area reddens and a scab forms, which in a few days falls off and leaves a beautiful cicatrized place. With deeper seated lesions the progress is slower.

Kaiser finds in common with others using light in tuberculosis pulmonalis that good results ensue, but little resistance being offered by the lungs to the beam of light. In two cases of tuberculosis of the lungs treated, there was noted after a few séances disappearance of the night sweats, improvement of appetite, increase in weight, and a diminution of the bacilli in the sputum, all of which is confirmatory of all other evidence adduced.

Two cases of lupus are detailed here as illustrative of the results to be obtained. All ultra-violet frequencies, of less wave length than 30 microcentimetres, are frankly excluded.

M. E., Lupus Vulgaris of the Nose and Right Cheek for Two Years.—The light was projected upon the part through the blue glass filter or screen. After the exposure there was a distinct reddening which soon became pale and left a strong scab. After the fortieth exposure there was a smooth reddened scar which, after the seventieth treatment, quite harmonized with the color of the surrounding skin.

E. P., Lupus Erythematosus for Four Years.—This had spread over both cheeks and the whole forehead. Prior to coming under Kaiser's care she had been treated by all available methods, but without results. At the time of the report there had been 72 exposures, as a result of which the redness had disappeared, and the patches, especially on the right cheek and forehead, were considerably smaller. The complete healing of the lesion was expected, from appearances, in two months time.

R. P., Tuberculous Ulcer on the Right Forearm for Two Years.—The size was variable, at one time being large, at another small. After 11 exposures the redness and irritation were less, and after 27 exposures a dry scab fell off, and there was complete healing.

Kaiser draws the following conclusions from his experimental and clinical observations:

"(1) Blue light considerably stimulates metabolism. (2) The action is mainly due to the more refrangible rays. (3) It is directly proportional to the distance and intensity of the ray of light. (4) Blue rays penetrate vascular tissue so easily that a deep effect cannot be denied. (5) They have a strong absorbent and anodyne effect, and in a concentrated state are slightly anæsthetic."[1]

Simply as a matter of interest in the history of the therapeutic use of light it may be mentioned here that Dr. S. Pancoast,[2] of Philadelphia, used blue light, as well as the other frequencies of the spectrum, nearly thirty years ago in his practice, and embodied his views in a curious book entitled "Blue and Red Light." Detailed cases are reported, and his blue and red rooms with the patient dressed in blue or red reclining upon a couch directly under the sunlight filtered through (1) blue glass window panes entirely, (2) blue and plain glass alternately, (3) red glass entirely, and (4) red and plain glass alternately are illustrated in colors.

The book is a curious one, full of the lore of the ancients, concerning light and its relation to life, as is illustrated by the following paragraph:

"The Kabbala declares that light is the primordial essence of the universe, and that all life and motion proceed from it; it is the vital dynamic force of nature. It also declares that it is by the study of light that we are enabled to acquire a knowledge of the unknowable or causal world. Light is Jacob's ladder, by which we ascend to Celestial Knowledge,

[1]The author believes that this is not true anæsthesia, but rather one of analgesia.
[2]Blue and Red Light. S. Pancoast.

the upper rundle being in the fourth Septira, represented by the Pentagram."

There is much of the Newtonian philosophy to be found in the ancient literature, and it is suggested by Pancoast that without doubt Newton had been exploring the old mines of Kabbalistic lore and had arrived at his great discoveries by following up clews gained therefrom. Be that as it may, there is no question but that in it there is much which, to the modern physicist, is very suggestive in view of the knowledge of to-day.

But one fact remains to be noted in this connection, viz., that one finds in Pancoast's recorded cases, "Sub-acute Rheumatism," "Sciatica," "Consumption," "Diphtheria with Paraplegia," "Cholera Infantum and Marasmus," "Nerve Exhaustion," etc., the same effects from the action of light with the same satisfactory results as are now obtained. The cases of rheumatism, sciatica, cholera infantum, and marasmus were treated by means of blue light, while the cases of diphtheria and consumption were treated with red light.

The calorific and luminous rays, Pancoast believed, must be excluded in smallpox as pernicious in their effect while the chemical rays were regarded as beneficial in their effect. His conclusion was drawn from the fact that smallpox patients kept in the dark did better than those in the light, showing how unsafe it is to try to deduce a scientific fact from a simple clinical observation.

Minim,[1] who has also especially studied the visible chemical frequencies of the spectrum from the blue to the ultraviolet, considers that they have an action on vaso-motor nerves, that they are endowed with analgesic qualities, and that they ameliorate or cure superficial neuralgias. The physiological action and therapeutic results obtained from the use of blue light is, therefore, due to the visible chemical frequencies. The best results are obtained by exposures to their

[1]Dr. A. W. Minim, St. Petersburg, "On the Therapeutic Action of the Blue Electric Light." The Journal of Physical Therapeutics, January 15, 1902.

action at a considerable distance from the source of light, showing that the effect is not obtained in any degree from residual thermal energy. His experimental work demonstrated that by the action of the isolated visible frequencies, blood vessels were constricted and marked anæsthesia produced, while the opposite effect was produced by white light. The anæsthesia established by these frequencies, he found to be as marked as that produced by cocaine. In his experience and also in that of others, the degree of anæsthesia produced is sufficient for the performance of minor surgical operations, without pain, and it also facilitates the cicatrization of wounds. Minim first observed the pain-alleviating powers of blue light from using it in pleurisies prior to physical examination, in order to render a tender spot tolerant to investigation. Subsequently he used it instead of cocaine to produce local anæsthesia where incisions and stitching of wounds were required as well as in the treatment of sloughs and in opening abscesses. He also determined experimentally that the action of blue electric light was the reverse of white light, i.e., that a granulating surface became anæmic under the influence of blue light and hyperæmic under the influence of white light. The following two cases are reported by Minim:

(1) Mr. X., a secretary of a foreign embassy, cut his finger with a piece of glass. The cut was on the outer side of the third finger, and about 3 cm. long. After a 10 minutes exposure to the light from a 50 candle-power incandescent lamp, enclosed in a blue glass bulb, two stitches were made without pain. Healing commenced at once, and was completed in four days.

(2) A soldier of the Bodyguard Cavalry Regiment cut the dorsal surface of his left thumb, the wound being about 3 cm. long. After cleansing the wound it was exposed to blue light for 10 minutes, as in the preceding case. Three stitches were then introduced, involving no pain. He was engaged in conversation during the time, and did not attend to what was being done, stating that he thought "a

soft cotton ball was pressed on the wound." On the third day healing had taken place by the first intention. He also found that contusions due to falls were promptly cured by their action.

A case of burn of the first degree yielded to two applications of the visible chemical frequencies from a lamp of 50 candle-power, each exposure 10 minutes in duration.

In a case of injury to the mouth, throat and œsophagus, caused by the accidental ingestion of ammonia, several applications of the blue light accomplished a complete cure. The exposures were made (1) to the mucous membrane of the mouth, and (2) to the front of the neck and chest.

An application of white light, from a 50 candle-power lamp, followed by a few minutes' exposure to blue light from a 25 candle-power lamp, established a cure in a case of rheumatic purpura. In a case of simple purpura, five applications of light cured the patient after other remedial agents had failed. A beneficial effect upon the patients' general health was also obtained. Among the conditions treated by Minim with the visible chemical frequencies, according to his method, may be mentioned burns, hæmaturia, acute myelitis, articular rheumatism and pleuritic pains. Minim finds that bloody effusions are absorbed more quickly when treated at the end of three or four days than immediately after. He observed that the analgesic and absorptive action were greater with blue than with white light. The gradual diminution of the pain and effusion in contusion and ecchymosis is rapid.

Upon examination of a wound treated by means of blue light, punctiform islets are observed to appear upon surface, which rapidly increase, then fuse. The papillæ become rosy, then yellow; the blood which covers the papillæ dries, forming a protecting crust.

Brockbank[1] also reports two cases of minor surgical operations done under blue light anæsthesia. He unfortunately, however, attributes the action to the ultra-violet frequencies, entitling his report "Ultra-Violet Ray Anæsthesia in Minor Surgery." With the Minim lamp, by reason of its glass enclosure, there are none of the ultra-violet frequencies, as glass is not transparent to them. The frequencies utilized by him and also by Minim are the visible chemical frequencies, i.e., the blue, indigo, violet to the ultra-violet of 30 micro-centimetres in length. The cases reported by Brockbank are of greater severity than those detailed by Minim, and are quoted as illustrative of the analgesic action of light.

[1]Ultra-violet Ray Anæsthesia in Minor Surgery. Am. Med., April 25, 1903.

Case I.—Suffered from a clean incised wound of the left forearm, extending from the head of the ulna parallel with the bone for two inches, exposing the tendons of the muscles in that region throughout their entire length. The parts were cleansed in the usual manner and then exposed to the rays of light from a No. 4 Minim lamp for 15 minutes, after which 5 interrupted silk sutures were placed without causing the patient any discomfort. The area was dusted with an antiseptic powder, equal parts of urasol and aristol powder, covered with a 10 per cent. iodiform gauze, a compress of absorbent cotton and a small roller bandage. The wound healed without trouble.

Case II.—Fatty tumor just below the left breast. Patient had been advised to have it removed, but had not done so because of her dread of anæsthesia. The site for the operation was thoroughly cleansed, then exposed to the rays of a No. 4 Minim lamp at eight inches for 20 minutes, and at slightly greater distance during removal. An incision two inches long down to the tumor was made without causing sufficient pain to give any distress. Adhesions were then broken up and the tumor shelled out without difficulty. Pressure readily controlled the slight hæmorrhage, and the edges of the wound were brought together by fine interrupted silk sutures without complaint on the part of the patient. The wound was dressed with antiseptic powder, iodoform gauze and compress held in place by adhesive

strips and a roller bandage. No shock, distress, nor discomfort of any kind followed the operation. An examination of the dressings on the second day found them perfectly dry, and on the fourth they were removed. The wound was perfectly healed and the stitches were removed. An iodoform gauze dressing was then applied for two days longer.

Tracy[1] also reports a number of surgical cases in which the anæsthesia was produced by the visible chemical frequencies and healing hastened. He, like Brockbank, wrongly attributes the action to the ultra-violet or invisible chemical frequencies, instead of the blue or visible chemical frequencies.

In one instance a large sebaceous cyst—an inch in diameter—was removed from the scalp without pain under the influence of blue light anæsthesia. The application at distance of two inches was 15 minutes in duration from a No. 3 Minim lamp. Two incisions, each one inch in length, were made and an elliptical piece of skin removed. The cyst was shelled out and four running stitches placed. No pain was experienced, and patient expressed surprise when he saw the tissues removed. A 10 minute exposure, subsequent to operation, was made as an antiseptic precaution. Healing by first intention was established the second day, and on the third the stitches were removed. Complete union did not take place until the fifth day, owing to the formation of a blood-clot underneath the united skin flaps. The parts were exposed daily to blue light for five days.

A subcutaneous abscess involving the distal joint of the thumb was operated on painlessly under the influence of blue light anæsthesia, and recovered completely without bandaging or dressing of any kind, in four days, under daily exposures to the light, the patient going back to his work as a car conductor on the fourth day.

In a skin slough of one inch square and one thirty-second

[1]E. A. Tracy: Skin Anæsthesia produced by Actinic (ultra-violet) Rays from Minim's Apparatus, Boston Medical and Surgical Journal.

of an inch deep, due to an injury twenty-four hours previous, of a dirty opaque dark green color, involving the palm of the hand, curettement was made painlessly under blue light anæsthesia. A 10 minutes exposure to the blue light was made immediately after the operation, and an exudate of clear serum was seen to form upon the raw surface. This was wiped off and a piece of cotton compress without any dressing was applied with a bandage. Healing was established in two days save where the cotton had adhered. The removal of the adherent cotton caused bleeding, which ceased and the tissues assumed the characteristic glazed look, as though covered with a thin film of gelatin under exposure to the light. Cotton compress and bandage applied. No further care required. Complete healing.

The removal of the exudate of clear serum from the curetted surface, in the author's opinion, was a mistake. The action of the light had only stimulated the natural process of repair in the first stage, and the chances are if it had not been interfered with that healing would have been established without the adherence of injured tissues to the cotton dressing.

A piece of a broken needle was removed from the forearm painlessly after a 10 minutes exposure to blue light. Tracy states that he has applied blue light several hundred times, witnessing an untoward result in only one instance. This occurred in a case in which the patient's forearm had been burned severely when she was a child. This scar tissue proved very sensitive to the action of the light and following a 20 minutes exposure of the part, a blister formed after 10 hours in no sense different from one produced by a sunburn.

No further complication is reported in this case than the formation of a blister, and that should not in any sense be regarded as an untoward result if it were produced by the chemical energy only. If, however, the thermal energy were active as well, the healing process might be complicated by reason of the two following conditions: (1) Scar tissue is imperfectly organized and nourished as compared with nor-

mal tissue, hence (2) thermal energy would tend to the establishment of an inflammation, which would result disastrously to the integrity of the skin involving the scar tissue. Such would not be the case from the chemical energy. The reaction established might easily be sufficient to cause blistering of the epidermis, but upon its subsidence there would be no destructive action upon the skin and underlying cellular tissue from an exposure of the length specified and from a source no more powerful than a 32 or a 50 candle-power incandescent lamp.

The following case[1] is similar in result to the previous cases, but for it all the energies of a 25 ampère arc were used. As the result obtained in the previous case was by the exclusion of all but the visible chemical frequencies the latter is quoted here to contrast the one method with the other. It seems to be conclusively established that it is the chemical frequencies which are the active part of the spectrum in relieving congestions and inflammations. If the chemical light intensity is not too great there is no need for the exclusion of the ultra-violet.

Mr. G.—March 26, 1904.—Aged 26, has suffered from enlargement of the epididymis, with pain and induration for the past four years. Has grown steadily worse, although under medical care during the past year. Diagnosis Epidymitis. On the day he presented himself for treatment, a high frequency current was applied to the parts, resulting in a very great deal of irritation and discomfort, confining the patient to bed for two days. At his second visit, the beam of parallel rays from the marine searchlight, at full ampèrage (25 ampères), 6 inches in diameter, was projected upon the parts for 15 minutes. The tumor, which at the beginning of the administration, was larger than an almond, was reduced to one-half the size from the one exposure, and all pain and irritation were immediately relieved. The patient did not report for two weeks, because he had no trouble.

[1] Dr. W. B. Snow: Personal communication.

The following notes of cases treated by Minim's Blue Electric Light, from June, 1903, to June, 1904,[1] were furnished the author by Dr. H. W. Barnum.

Case I.—Man with greatly swollen hand from bee sting, exposure to a 32 candle-power lamp for half hour at 10 inches, rays falling perpendicularly on the part. The swelling was reduced one half during the treatment and by the next morning was so nearly gone that patient declined further treatment, declaring he was cured.

Case II.—Man with enlarged gland, right groin, skin red. Same treatment as in first case except longer time (45 minutes), daily for a week. Cured. Cause of swelling unknown. At the time he complained of poor health, fearing tuberculosis. He spent the winter of 1903-1904 in Florida and was seen recently in good health.

Case III.—Man with enlarged gland at angle of left lower jaw, caused probably by a decayed tooth. Daily exposures to the blue light energy as above for 30 to 45 minutes. Cured in fifteen days.

Case IV.—Man with pain, swelling, soreness in mastoid process, right side. Earache two months previously, discharge for one day. Muscles stiff and sore, could not turn head nor lie on that side. Blue light as above, 40 minutes daily one week. Cured. Relief was marked after first treatment.

Case V.—Woman with bruise of tibia midway between knee and ankle. The first injury was three years before calling on Dr. Barnum. Had bruised it twice after that. Pain, redness. Blue light for seven days, half hour each day. No trouble since—one year.

Case VI.—Woman with severe bronchitis three weeks. Blue light, three treatments, almost entirely cured. Have treated several similar cases with similar result. Have had good results in chronic bronchitis also.

Case VII.—Woman with severe X ray blister. The blue light used daily undoubtedly hastened healing.

[1] H. W. Barnum, Poughkeepsie, N. Y.: Personal communication.

Dr. Barnum in common with the author has never been able to produce a true anæsthesia by means of the blue light energy.

General Pleasanton, of blue glass fame, claimed to have effected complete cure in a case of contusion by three exposures, each half an hour in duration to the visible chemical frequencies. In view of the preceding reports the correctness of his statement must be regarded as substantiated.

Neuralgia.—In the treatment of neuralgia by means of light energy, Arienzo[1] has used a 30 candle-power incandescent lamp of blue glass provided with an ordinary reflector. The patient was placed 15 centimetres, between 5 and 6 inches, from the source of the light. Exposures were made daily, in 4 cases of neuralgia of the trigeminus, one of the auriculo-temporal and one of the spermatic nerve, all of whom were speedily relieved by the treatment. The cases averaged 10 exposures each save one, in which 20 were made. Arienzo also is of the opinion that the visible chemical frequencies penetrate the tissues and the subjacent organs, and that they have a special action upon the vasa nervorum.

The influence of the Visible Chemical Frequencies or Blue Light upon Catarrhal Inflammations of the Throat.—E. A. Pietnikoff[2] has employed blue light in the treatment of acute catarrhal inflammations of the throat. He reports five such cases with the following results:

(1) The course of the disease was considerably shortened; (2) after the first sitting the action of deglutition became much less painful; (3) the exudate disappeared after the first or at the utmost, the second sitting; (4) the diffuse redness of the mucous membrane disappeared speedily after the second treatment; (5) the swelling of the tonsils diminished markedly after the first sitting, the fever also subsided after the first treatment.

In these cases a 50 candle-power lamp, 110 volts, covered

[1]Journal de Medicine de Paris, Jan. 17, 1904.
[2]E. A. Pietnikoff, Bolnitchnaia Gazeta Botkina, Vol. XII., No. 19.

with a blue glass bulb was used. It was placed in the centre of a reflector, at sufficient distance from the patient to prevent any sensation of heat. The light rays should be directed perpendicularly toward the throat and tonsils, and the application made from 10 to 15 minutes. In his cases, Pietnikoff made the application in this way, with slight interruptions during a séance, dependent upon the patient's fatigue from the position necessary. He thus obtained only the visible chemical frequencies.

Action Wrongly Attributed to the Ultra-Violet.—Tracy and Brockbank, in common with many other writers, attribute the action to ultra-violet frequencies. Such is not the case. The patient is effectually shielded from such ultra-violet frequencies as are present in an incandescent lamp, because of its glass covering. Similar results are obtained from the action of white light, and are considered under that head.

Visible as well as Invisible Chemical Light Energy Useful.—These clinical cases, as well as others, indicate the value of the visible chemical frequencies of light as well as the invisible, and show that they have decided therapeutic properties. The experiments of Kaiser, as well as clinical experience, show them to be antiseptic, and also to possess resolvent qualities.

Power of Blue Light to Produce Analgesia.—Their power to produce an analgesia seems to be conclusively proven. A local anæsthesia should as surely follow an expenditure of energy from the chemical end of the spectrum as from an expenditure of energy from a chemical substance topically applied or injected within the tissues. This being the case, the choice lies with the individual operator. It naturally follows that the physician equipped with electric light apparatus, and understanding its value, should use it in preference to other means. Moreover, in addition to this reported ability to produce anæsthesia by this means, there is the additional advantage of the stimulating effect upon the injured tissues, tending to their prompt restora-

tion to the normal. In the author's experience with Minim lamps of 16 to 50 candle-power no such anæsthesia has been produced in the persons of two physicians, i.e., no annulment of sensation, but there was an analgesic condition following the use of blue light. There is, however, every reason to believe both on physical grounds and from clinical observations, that etheric vibrations, whether of the frequency to produce light or an electric current, are capable of analgesic and possibly anæsthetic properties. These observations are a matter of record, with alternating currents of high frequency, and have occurred in the author's experience in the use not only of the chemical frequencies of light energy, but with the current of tension from the secondary of an induction coil, and also from a high frequency of the sinusoidal current. The most interesting and convincing experiments with the sinusoidal current were made by Professor Scripture, of Yale, and reported to the American Association for the Advancement of Science several years since. His experiments were made with a Kennelly alternator. A frequency of 5,000 complete periods per second, 10,000 alterations, was made to traverse a nerve with the result of cutting off sensory communication by this nerve, and needles were run into any part of the body supplied by the nerve without pain being felt. Groups of nerves, for example, the brachial plexus, was cut off in a similar manner. The analgesic and possible anæsthetic effects of currents of high frequency are the same in kind as those produced by light. The agents differ only in rate and wave length.

It is the prolonged applications of these stimuli which renders them tetanizing. Stimuli which are applied at long intervals to the nerve act especially on the vaso-dilator fibres. On the other hand, tetanizing stimuli act on the vasomotor fibres. The latent period of the vaso-dilators is longer, and they are more easily exhausted than the vaso-motors.[1] In

[1]Landois and Stirling, Bowditch and Warren, p. 865.

the one instance the active energy should on physical grounds have the proper period of vibrational activity to reëstablish normal atomic motion and also be delivered at intervals, the sudden impulse of an electrical current, for example, while in the latter it is necessary that it should be a rhythmic energy delivered for a prolonged period of time.

Visible Chemical Frequencies Useful in Other Conditions than Surgical.—But the visible chemical frequencies are useful in a great variety of conditions other than those invoking the need of surgical measures, and preceding anæsthesia. By reason of their great penetration and absorption by the blood, in common with the invisible chemical frequencies, they are useful wherever it is desired to control congestion, inflammation even, in all structures within their reach, and they act by their direct oxygenating power.

Not only the pains of burns, open sores, congestions, inflammations, are relieved, but circulatory and absorptive conditions are initiated, resulting in the healing of the former, and the establishment of normal processes in the latter. They act energetically in the removal of ecchymoses following contusions, securing prompt absorption.

While the author uses, as a rule, the entire range of the spectrum from the red and including the ultra-violet, eliminating the heat only, in the class of conditions to be mentioned, others have excluded all but the visible chemical frequencies. The results from the two methods are apparently the same, and the fact that they are obtained without the green, yellow, orange and red, indicates that it is the visible chemical frequencies that are active. This naturally follows from a consideration of their frequency and wave length, i.e., rate of vibrational activity, which influences vibrational activity of molecular structure. It has been pointed out in discussing the physical action of light, that groups of molecules are more probably acted upon than atoms, but there may be an action due to sympathetic resonance or synchronous vibration as well.

But it is fully in accord with known laws to expect an effect from the physical action of light frequencies, even though their period of motion is not in synchronism with that of individual molecules or even groups of molecules.

General Applications of the Visible Chemical Frequencies.—But the action of blue light is by no means confined to localized lesions. If desired, the electric light can be projected upon the entire body through the medium of blue glass. By the use of blue glass in this way, the resultant frequencies are from the visible chemical region, and the action is a chemical one, but less strongly chemical than from the unprotected arc. Still, as has been stated, they are sufficiently active to produce pigmentation of the skin, capillary dilatation and hyperæmia with more complete oxygenation of the blood, as well as a stimulating action upon the organism, through the resultant, chemical, osmotic, and molecular activity which ensues; an effect in kind, but not in degree, of that of the unprotected arc.

The experiments of Pansini point to a special action of blue light, which gives it still further place in therapeutics. From the increased muscular work done under its influence, as demonstrated by ergographic tracings, it should have the power to promote muscular tone in the patient whose tissues are soft and flabby. For the best influence upon the red blood corpuscles, or oxygen carriers of the blood, it is probable that the unprotected arc, rich in ultra-violet frequencies, is the better means, but afterwards, to increase muscle tone, the intervention of blue glass might be desirable. Personally, the author has not so discriminated, but there is the possibility, based upon photo-biological research, that it might be well to so discriminate.

However, by reason of its intense chemical activity and action upon the blood, blue light from a number of incandescent lamps should serve the purpose of a general tonic treatment.

In addition, both experimental evidence and certain clinical data point to an effect upon the nervous system which

is fully considered under that head. The question which remains to be conclusively established is whether better results follow the use of all the energies of an electric arc or whether the exclusion of every activity other than the visible chemical region is desirable in this class of cases. Where it is desired to act directly upon an unduly excitable cerebrum, on theoretical grounds certainly, as well as upon a certain amount of biological research, all but the latter should be excluded.

The Influence of Chemical Light Energy in Precipitating Hysterical Attacks in Anæmic Patients.—The observation has been made by Minim and others that the action of the visible chemical frequencies may either provoke or exaggerate hysteria in anæmic patients. The author has seen one case of neurasthenia with intense spinal irritability associated with extreme weakness of legs, arms and throat, due to the exhaustion of the spinal centres, complicated by a major hysteria, in which all the symptoms were increased for five to six days from an application of the concentrated and condensed chemical frequencies visible and invisible, of five minutes' duration over the sensitive spots, i.e., at the cervical enlargement and the middle of the dorsal region. In this same case an application of the convective discharge from a static machine always excited hysterical manifestations.

Acute Processes Aggravated by an Expenditure of Chemical Light Energy.—Processes characteristic of the conditions which have been enumerated are much more favorably influenced when not of long standing than the more chronic ailments, whether the expenditure of energy comprises the whole of the chemical end of the spectrum—visible and invisible, the visible spectrum only—or white light.

On the other hand, if an acute eruption is exposed to the action of these frequencies, the chances are that the condition will be aggravated, as has been established by Finsen, in the management of smallpox.

The untoward action of these frequencies in acute cutaneous processes, or an acute inflammatory condition elsewhere, is governed by the same laws as an expenditure of any form of energy—electrical or chemical—for example, in the same class of cases.

The use of the continuous current, with its deeply penetrating chemical action, or the topical application of strong chemicals, may in acute processes establish a condition of even greater over-activity of the part. Just so with the chemical end of the spectrum. When it is fully appreciated that one is expending energy capable of profound chemical action, by the use of blue light, its action will not only be much better understood, but savor less of the occult, or as an agent for good by reason of its suggestive influence only. It is not the author's purpose or function to discuss the therapeutic value of the latter method, but great as it is, it is not necessary to use it as an explanation for an influence or condition established by a direct expenditure of chemically active energy.

Summary.—The amassed clinical evidence points to an action upon the vaso-motor nerves. (1) The first action seems to be a vaso-constriction. This is probable, as the first impingement of an electric current from the continuous on up the scale, invariably acts to produce a vaso-motor constriction primarily, the dilatation and equalization of the circulation following in the order given. In this way the tissues are rendered anæmic; and (2) an anæmia tends to an analgesia and possibly anæsthesia. When too long an application or exposure a hyperæmia results; (3) by the use of blue light a soothing effect is produced on the nerves. It is quieting and von Jaksch[1] emphasizes the soothing soporific effect of blue light and uses blue glass chimneys upon lamps in his sick wards; (4) by its use healing of wounds is promoted; (5) exposure to blue light energy increases the power to do muscular work (Pansini).

The Minim Lamp.—In order to bring the visible chemi-

[1] XX. Congress f. innere Medicine, 1902.

cal frequencies of light within the reach of the general practitioner, Minim devised the arrangement of light mechanism bearing his name. It is inexpensive and portable, but not superior, as has been claimed, to the original arrangement of arc light mechanisms used by Finsen, or the many other arc light mechanisms in use both in this country and Europe. They are, to a certain extent, interchangeable in their uses, but the Minim lamp can in no sense take the place of the arc lamp, not alone because of the glass enclosure, limiting thereby the ultra-violet frequencies, but because the quantity

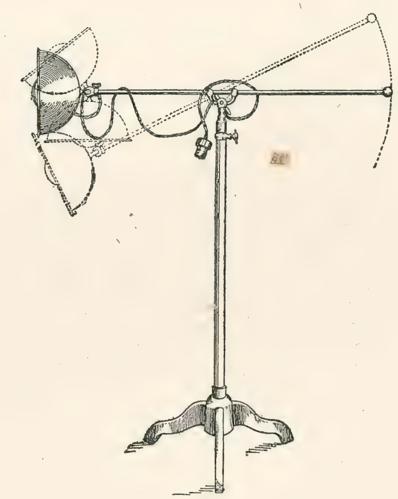

Fig. 32.

of light is absolutely inefficient in the deeper seated, longer standing, and more fully organized morbid processes. It is one thing to secure brilliant results in the production of anæsthesia in limited areas, the perfect sepsis and healing of superficial wounds, the relief of pain in recently injured joints, but it is a different matter to successfully combat or modify more extensive and profound pathologic states, for example, the deeply infiltrated and indurated tissues of old lupus cases, pulmonary tuberculosis, spinal cord lesions, as in locomotor ataxia. Here it becomes a matter of a much

greater expenditure of energy than is possible with an incandescent lamp. The greater the expenditure, the more profound the influence, and to that end the more powerful sources of light, as the electric arc, should be used. And in the event of the visible chemical frequencies alone being desired from the arc, the light should be projected through the media of a blue glass screen.

The apparatus (see Fig. 32) consists of a stand similar to those used for the crown electrode of a static machine, into which can be fitted at will one of the three incandescent blue glass bulbs, 16, 32 and 50 candle-power, and known as lamps Nos. 1, 2, and 3, respectively. Each of these bulbs is provided with an aluminum reflector, ranging from 6½ to 9 inches in diameter.

In addition there is a ground-glass bulb used for frictional applications to a part.

The reflector is adjusted to the stand, as shown in Fig. 32. The lamp socket is pushed into the opening of the reflector, to which it is securely held by clamps, and whichever lamp the operator desires to use is screwed into the socket at the base of the reflector.

The plug in the end of the cord is screwed into an electric current socket. Either the direct or alternating current can be used according to the source of the E. M. F. with which the physician's offices or patient's house is equipped. The bulbs for these different currents are not interchangeable, owing to their different construction.

The reflector serves to project the rays of light upon the part to be treated, and by means of it it is possible to utilize the maximum energy of the visible chemical region which can be obtained from the source of light in question. No reflector is used with the ground-glass bulb.

Technique of the Minim Method.—Minim has formulated the following technique for the use of the method known by his name: (1) The rays must fall directly on the part to be treated, and not at right angles thereto. (2) The reflector containing the lamp bulb should be adjusted at such a distance that the patient will perceive a feeble sensation of heat. (3) Daily exposures of the affected part should be made, from 10 to 15 minutes each, or from 25 to 30 minutes every other day. If severe itching of the skin occurs, treatment should be omitted for at least two days. (4) If there is pain in the parts to be treated, the skin should be washed before the exposure with equal parts of alcohol and a one per cent. boric-acid solution. Should there be no pain, then the alcohol should be used alone. When a joint or muscle has been treated by means of the blue light, then the part should be gently rubbed with the ground-glass lamp. The rapidity of movement is governed by the condition of the parts as to tenderness.

While these are the rules laid down by Minim, the individual operator will modify according to the individual case. The use of the alcohol, in the author's opinion, simply serves to make the skin more susceptible to the vibrational activity of the light.

Given an equipment of which the electric arc forms a part, the author prefers it to the lesser energy of the incandescent lamp; but as the rank and file of the profession may, if they desire, avail themselves of the latter when they could not of the former, it is commended to their attention.

In the ground-glass lamp, as used in the Minim method, the intense thermal activities are modified, and there remain the frequencies from the red to the edge of the ultra-violet, or white light.

By its use in connection with the blue light, the cutaneous circulation of any part of the body exposed to the light activities is stimulated, metabolism and absorption are promoted and not only local nutrition, but general nutritive activity is favored. While in any given local lesion the best result is secured by a general as well as local exposure, still the influence of the latter extends far beyond the bounds of the immediate area acted upon. Not only is pain relieved by the effect upon the peripheral nerve endings, but an anæsthesia sufficient for minor surgical measures is produced as well.

CHAPTER XV.

The Non-Concentrated Frequencies of the Red Region of the Spectrum or Red Light. Exclusion of all Above the Red in Smallpox and the Exanthemata. Finsen.

Red Light Energy.

Exclusion of All Light Energy Save the Frequencies of the Red Region of the Spectrum as a Preventative Measure in Smallpox and the Exanthemata—Introduction.—Red light is not only valuable in the treatment of smallpox but of measles and scarlet fever as well. It is here by the absence of the intensely actively chemical energy that good results. Still, it must be recognized that all the visible frequencies are, to a greater or less extent, chemically active; but it is the short and high frequencies of the greatest refrangibility which act chemically in relation to the skin.

Were red light synonymous with heat, it would be contraindicated in such febrile conditions as smallpox, scarlet fever, measles, etc., for the organism would not bear the prolonged application of a greater heat under such conditions. There would unquestionably be established a thermostasis or retention of heat which would result unfavorably.

Finsen is authority for the statement "that no ray of light should ever be allowed to fall on a smallpox patient unless it has passed through something red." The theory advanced by him is that red light in smallpox does not act as such, but by the exclusion of the chemical frequencies, especially the ultra-violet. By a series of experiments he proved that if the chemical frequencies are intercepted the remaining rays are innocuous and that a smallpox patient may be exposed to them a whole day long without evil conse-

quences. Schamberg[1] controverts this view, but as his statistics comprise only two cases in addition to his theoretical considerations they cannot in any sense be regarded as conclusive. The exclusion of the chemical frequencies is not only an extremely rational theory but one supported by much and very conclusive experimental evidence as well as 150 cases successfully treated in this way. Schamberg believes that it is impossible for diffuse winter daylight to have any irritating effect upon the skin. He also believes that the eruption of smallpox has a greater predilection for the face and extremities by reason of their great vascularity. He reasons that if the theory of Finsen is correct, negroes should suffer less from pitting than the white, because of the pigmentation of the skin, and therefore the inability of the chemical frequencies to penetrate and cause irritation. In his opinion, the vaccinal condition governs the result, not the exclusion of the chemical frequencies of light. In this view the author does not concur. The physical action of the penetrant chemical activities upon the blood stream, in addition to much experimental work and therapeutical result, all very clearly point to the chemical frequencies of light as the causative factor in the severe inflammation of the skin, involving cellular tissue, characterizing not only smallpox but erysipelas. When it is considered that a 5-minute application of concentrated light energy from a 17-ampère arc, used with but one-third of the controlling resistance, from which the heat is filtered out, will produce in 20 minutes a redness extending over an area the size of the compressing lens, which increases in severity of reaction, i.e., sense of burning, as though the part had been blistered as well as in intensity of coloring, for 24 hours or more, it is not possible to hold any other opinion.

Historical.—The views of Finsen with reference to the employment of the red frequencies in smallpox have been disseminated and discussed during the past few years.

[1]Schamberg, J. F.: The Journal of the American Medical Association, May 2, 1903.

During his researches into the action of the chemical frequencies upon the skin, Finsen chanced upon a pamphlet in the medical library at Copenhagen, published in 1832 by Dr. Picton of New Orleans. In the pamphlet was the accidental mention of the fact that, during a certain epidemic of smallpox, some soldiers confined in dark dungeons had suffered the disease and recovered without suppuration or scarring. No explanation of the phenomenon was made, but to Finsen, whose experimental work had shown him so clearly the nature of the action of the chemical frequencies upon the skin, the explanation came as quickly and vividly as a lightning flash. The soldiers in question had recovered without scarring simply because being in dark cells they were protected against the action of the irritating chemical activities. Although he had never seen a case of smallpox, he came to the conclusion entirely on theoretical grounds that exclusion of all but the red frequencies would effectually prevent scarring and pitting, and presented within a month after the question suggested itself to him his red light treatment of smallpox. The red light treatment of smallpox had been successfully practised before in the popular medical practice of centuries past and according to Finsen[1] the face and hands of smallpox patients in China, Japan and Roumania were swathed in red cloth and graver symptoms averted. It was also practised in England several centuries ago.

John of Gaddesden,[2] who wrote the famous medical treatise, the earliest in the English language, "Rosa Medicinæ," and who died in 1361, treated the son of King Edward I. for smallpox by covering him with scarlet blankets and a red counterpane, placing him in a room in a bed with scarlet hangings, gargling his throat with mulberry wine, and having him suck the juice of red pomegranates, and the patient recovered, never showing any trace of smallpox.

[1]Ueber die Bedeutung der chem. Strahlen des Lichtes, etc., Leipzig, 1899.
[2]Philadelphia Medical Journal, Dec. 7, 1901.

Such, says Gregory, writing in 1843, was the boasted prescription of John of Gaddesden, who took no small credit to himself for bringing his royal patient through the disease. Also back in the time of Queen Elizabeth, the value of red curtains, red coverlets and red glass about the bed in smallpox cases was loudly proclaimed by certain doctors, who were regarded, as was John of Gaddesden, as charlatans by the orthodox physicians of the day. There is also some evidence that other physicians in different times and places have believed in the virtues of phototherapy and adopted it to cure certain forms of skin disease.

In 1867 Black[1] revived the question of the influence of light in smallpox, claiming that the complete exclusion of light, even in unvaccinated cases, effectually prevented the pitting of the face. In 1871 Waters[2] stated that by the exclusion of daylight there was no doubt but that the disease was less severe; while Barlow[3] observed that there was a marked contrast between the conditions of the two sides of the patient's face, one of which was covered with a colored gelatin to exclude the chemical rays of the sun, while the other was exposed.

The author, however, has never chanced upon any scientific explanation based upon experimental work for the exclusion of all the frequencies above the red, prior to that given by Finsen himself.

Therapeutic Results.—At the time of Finsen's solution of the question, it happened that there was much smallpox in Bergen, Norway, and Dr. Lindholm, Chief of the Military Service, suggested to Svendsen,[4] his assistant, that he make a trial of the red light treatment. The first test was made in August, 1893, on 8 smallpox patients, 4 of them children, who had never been vaccinated and were bad cases. Almost all presented some confluent vesicles on the face and hands. The results substantiated Finsen's theory and was summed

[1]Lancet, June 29, 1867.
[2]Lancet, Feb. 4, 1871.
[3]Lancet, July 1, 1871.
[4]Hospital stidende, Sept. 6, 1893.

up by Svendsen as follows: "The period of suppuration, the most dangerous and most painful stage of smallpox, did not appear; there was no elevation of temperature and no œdema. The patients entered the stage of convalescence immediately after the stage of vesiculation, which seemed a little prolonged. The hideous scars were avoided."[1] Svendsen practised also on two patients a most illustrative experiment. They presented upon the face some vesicles withered by the red light treatment, but their hands were covered with vesicles still in activity. Now these patients exposed to the sun presented no modification upon the face, while the vesicles of the hands ended in suppuration. A few months later Dr. Benckert[2] of Gothenburg, Sweden, tried the red light, stating subsequently as the result of his experience, that in grave cases of smallpox it gave the most surprising results, that suppuration was usually abolished, scars extremely rare, and if they do occur are insignificant, the duration of the disease is also shorter.

Montague L. B. Rood,[3] surgeon in the Royal Navy, used the red light preventative measure in 1897, the results surpassing his highest expectations. The following report was made by him: "A blue jacket was received on board a gunboat I was then serving in from the flagship on the China station at a port in Corea for passage to hospital at Nagasaki. His temperature was 103 degrees, rapid pulse, furred tongue, headache, and the patient very ill. He was in the second week of the disease, but suppuration was slight. There was an abundant eruption over the face, scalp, back of the hands, and a less abundant eruption over the trunk and limbs. He was placed under the forecastle in a swing cot, and enclosed with a canvas screen. The only light was supplied by two scuttles, which were covered with thick "red bunting" (used for making flags). He was treated in the usual way with liquid diet and tepid sponging. In two days

[1] Medicnisk Rev., Oct., 1896.

[2] Contribution to the study of phototherapy, Thèse, Lyon, 1900. Bayle.

[3] British Medical Journal, Dec. 5, 1903.

the temperature had fallen to 99°, and there was a very marked effect on the eruption, and his general condition much improved. He made a rapid and uninterrupted recovery, although the light preventative measure was not carried out after he was placed in hospital at Nagasaki. There is nothing new in this communication, but is one more positive proof of the efficacy of this light treatment, and it may help others in a similar position to try it."

It is difficult to appreciate at this time both the horrors presented by the constant presence of smallpox and the very grave disfigurements following it, before the custom of immunization prevailed. In most countries the custom of vaccination prevails. This is not true in Egypt, and Engel[1] found there ample opportunity for collecting pathologic and therapeutic knowledge from thoroughly typical cases. He had the opportunity of testing Finsen's method in a small but severe epidemic in Cairo and vicinity. The epidemic was stopped by wholesale vaccination.

Twenty-five cases only, but all of a severe type, could be dealt with in the pavilion arranged to carry out the treatment, according to the method of Finsen. Four (or five) cases ended fatally. In another pavilion all the other cases were treated and showed a nearly equal mortality. Engel regarded the number of cases as entirely too small to give a reliable comparison of statistic averages. However, it was clearly shown that the red light treatment did not seem to have any influence on the appearance of the rash, save that the hemorrhagic variety was never seen. The good effect was very evident, when the rash had already appeared, save in the case of mucous membranes.

In recent eruptions the formation of pustules was interrupted, in slight cases pustulation prevented, and in severe cases the severity and duration were considerably mitigated. No lasting or serious complications occurred and no deep radiating loss of tissue even in confluent cases. In the four

[1] Engel: "Therapy of the Present Day," May, 1901.

typical cases in which death occurred the throat, upper air passages and bronchi were very severely affected, the condition being accompanied by high temperature. As a rule, the exclusion of the chemical frequencies exercised a beneficial influence, unless the mucous membranes were affected. The secondary fever, depending more or less upon the inflammation of the mucous membranes, is always a very dangerous symptom. Multiple vaccination, i.e., in more than one spot, did not seem to exercise any better protective influence than single vaccination.

The consensus of opinion is that this method results in the total or partial suppression of suppuration and its concomitant fever, and the absence of scarring. Such scars as are left are mostly only superficial smooth hyperæmic patches which clear away later. There is no deep spreading loss of substance, but at most shallow depressions. As severe ulcers of the skin were avoided there were no resultant serious general symptoms. The complete exclusion of light or darkness acts in the same way as red light; for with darkness as with red light the chemical rays are excluded.

A Possible Action of the Red Frequencies.—Freund believes that it does not follow that the red rays do not play an active part in this therapy. It does not, he says, seem improbable, when considering the action of the allied thermal frequencies, that the red frequencies too should have a beneficial effect. Engel's observation that the red light treatment of smallpox patients had no effect upon the mucous membranes of the upper air passages, that is, parts which are usually in darkness, supports his theory. The upper air passages are deeply situated in the surrounding tissues and do not readily permit of transillumination. A good test for the theory advanced by Freund that the red light may play an active part in this therapy, would be to utilize in so far as practicable lamps so placed as to expose these tissues directly and constantly to red light energy. If under the influence of transmitted red light better results were secured it would be evidence in support of his theory.

The author believes, however, that red light does not act as such in smallpox and the exanthemata but by the exclusion of the chemical frequencies.

Suppuration of the Vesicles Due to the Chemical Frequencies of Light.—In a comparatively recent article Finsen emphasizes the statement that it may be considered an irrefutable fact that daylight, and especially the chemical frequencies, have a most injurious effect on the course of smallpox, as the suppuration of the vesicles is due to the action of light. It is possible therefore to avoid the suppuration and its disastrous consequences by protecting the patients from the action of light. On the other hand there is no action by light on the smallpox infection itself, and death caused by the latter cannot be prevented by excluding the chemical rays; but the avoidance of suppuration is of the greatest importance, as the suppurative stage is most dangerous, and the greatest number of deaths is due to this process.

Further, the numerous complications and sequelæ due to suppuration may be avoided, as well as the disfiguring by pitting.

Since smallpox is a disease for which the public health authorities oblige the patient to go into a particular hospital, he has a right to ask that there he shall not be unnecessarily exposed to dangers that may be fatal, or at least liable to disfigure him for life.

It must, concludes Finsen, be considered absolutely unwarrantable on the part of the public health authorities to treat serious cases of smallpox in which suppuration might be expected in hospitals where patients are exposed to daylight. As to the private physician, it must be considered a gross shortcoming if, as soon as he diagnoses smallpox, he does not make preparations to prevent the patient from being exposed to daylight. Everywhere it is possible to darken the windows by curtains, and all the necessary light can be supplied by a candle.[1]

[1]The British Medical Journal, June 6, 1903.

Finsen's Technique.—In July, 1893, Finsen first treated acute exanthemata by the exclusion of all the energy of the spectrum above the red from the rooms occupied by them, filtering the light through thick red curtains or screens.

The following conclusions in relation to this matter are from Finsen's pen, and should be carefully weighed by every one using the method.

"(1) The exclusion of the chemical rays must be absolute. The thickness of the red material employed to filter the light depends upon its nature. If paper or thin cotton cloth is used, four or five layers may be sufficient. If quite thick woollen cloth or flannel, two or three layers will answer. It is easier to employ red glass, but in this event the glass must be very dark. In other words, it is necessary to protect the variola patient with as much care against the chemical rays as the photographer does his plates and paper. As to artificial light it is necessary not to use either electric light or any sort of light that is very brilliant. The globes and chimneys of lamps ought to be very dark. A wax candle is permitted because of its feeble light. It can serve for the examination of the patient and to light him at his meals.

"(2) The treatment must be continued without any interruption even to the complete drying of the vesicles. Even a short exposure to the daylight can produce suppuration with its sequelæ. It is then absolutely necessary to prevent the penetration of the light, for example by nailing the curtains securely that the patients and attendants who are annoyed at being in the semi-darkness may not open them and reduce thus to a nullity the good results hoped for by the treatment.

"(3) It is necessary to give the treatment as soon as possible from the appearance of the eruption, for the nearer the approach to suppuration, the more the chance of obtaining a good result diminishes.

"(4) This method does not exclude but permits all other treatment that the physician judges suitable.

"(5) Of course death from variola is not prevented by this treatment, above all before the period of suppuration.

"(6) If the patients are submitted in time to this treatment and if the above rules are followed, suppuration would often be prevented and the patient recover without cicatrices, or only with some few rare cicatrices, which are almost invisible. It is well to note that for six or seven weeks the skin remains covered with hyperæmic or pigmented spots. At the end of this time they disappear."

Exclusion of the Chemical Effective Energy.—This is sometimes termed a negative phototherapy. Finsen has raised it to a precise and scientific method for which he has formulated with care all rules. There is then no reason why it may not be scientifically followed in hospitals devoted to the care of these patients. There is a great mass of evidence upon this subject. In addition to those mentioned are Juhel, Strandgaard, Feilberg, Rinoy, Perounet, Oettinger, Moore, Krohm and Mygind of Denmark, Doel of Bergen, Backmann and Courmant of Lyons.

The latter formulates the objection that it is difficult to say that the room can be so perfectly free from chemically active energy that a photographer's plates would not be acted upon; and also that the treatment is extremely painful both for the attendant and the patients who presented a state of continual super-excitation.

Bayle[1] apropos of this notes the fact that at the Maison Lumière where photographic plates and papers are prepared and which was formerly lighted by a red light, because of the intense cerebral excitation on the part of the workmen, green was substituted for the red, when the cerebral phenomena ceased. The properties of the green in this relation are similar to those of the red. For the same reason it is recommended that green be substituted for the red as a preventative measure in smallpox.

[1]Loc. cit.

The Exclusion of the Chemical Frequencies in Measles.—Chatinère,[1] Backmann,[2] and Schüler,[3] were induced from the results obtained in smallpox to try the same method in measles.

In this disease the treatment was also successful. The hyperæmia was lessened and the laryngeal and bronchial symptoms improved. Schouli,[4] Festner[5] and Schüler,[6] report good results from the use of the same method in scarlet fever and erysipelas; the course of the illness being modified in duration and severity.

Schouli[7] has reported six cases of scarlet fever in which red light has been used as a preventative measure. Two were instanced prior to the report quoted from. The first of the remaining group of four was placed in the red room from the beginning of the eruption where he remained five days. The course of the disease was benign, uncomplicated, no albuminuria and at the end of the five days the eruption had totally disappeared, without a trace of desquamation.

The second case, aged 5 years, was "very spoiled" and his parents could keep him in the red room but two days. Desquamation was not prevented. In the third case the patient was only placed in the red room on the third day of an intense scarlatinal eruption. Because of this delay, despite the four days passed in the red room, there was a slight desquamation upon the abdomen, hands and feet. But this desquamation was less intense than usual, furfuraceous upon the trunk and very small scales elsewhere. The fourth patient reported showed the happy effect of the exclusion of light energy above the red the most satisfactorily of the group. The child was placed in the red room on the first day of the eruption, where he lived for six days. There was absolutely no desquamation.

[1]La Presse Medic., 1898, No. 75.
[2]Quoted by Bie, Mitteilungen aus Finsen's Lichtinst., II., p. 150.
[3]Ibid.
[4]Refer. Zeitschr. f. diät. u. Phys. Th., Vol. III., p. 612.
[5]Quoted by Bie, Behandlung von Masern u. Scharlach mit Ausschl. d. sog. chem. Lichtstrahlen Mitt. aus Finsen's Lichtinst., II., p. 146.
[6]München med. Wochenschr., 1901, April 1.
[7]Phototherapy of Scarlet Fever, Analyzed in Bull. Med. Nov. 24, 1902. Journal de Physiothérapie, Jan. 15, 1903.

The advantages of preventing desquamation are: (1) Diminished duration of the disease; (2) a lessened severity of the disease in its later stages; (3) above all the diminished contagiousness.

The Exclusion of the Chemical Frequencies in Erysipelas.—A member of the Dermatological Society of Chicago, who has used red light in the treatment of measles and erysipelas, reports negative results. On the other hand Krukenberg,[1] who reports 18 cases of erysipelas, states that the fall in temperature and the general amelioration of the symptoms were unquestionably due to the exclusion of the chemical frequencies. He is also of the opinion that the favorable action obtained from the use of ichthyol, of tincture of iodine, as well as various plasters, is due, in part, at least, to the protection insured the part from the action of the chemical frequencies. By reason of the pigmentation of his skin, the negro is protected from the action of these frequencies, and according to Däubler and Plehn, is much less susceptible to erysipelatous and phlegmonous inflammation.

Exclusion of the Chemical Frequencies in Operation for Peritonitis.—It has been suggested by Clinton[2] that the exclusion of chemical rays, during operation for general peritonitis, might insure a better result from operative measures in general peritonitis. He calls attention to the fact that many patients succumb, whose condition prior to operation does not indicate the gravity which the case assumes after operation. When opened, washed and drained, they promptly drop into a state of septic collapse, from which they do not rally. The effect of the operation suggests that a severe infection has been stimulated in a severe manner. He asks what is known of the necessity for the presence of sunlight in the development of bacteria. It is his belief that strepto-

[1]Munich Medical Wochenschrift.
[2]Annals of Surgery.

coccus infection of the skin will not occur in the absence of sunlight or active rays. This is seen in smallpox, where the secondary pustular period will not develop if actinic rays be absolutely excluded from the patient. He regards the analogy between this condition and acute general peritonitis apparently as strong as between the curing of lupus and tubercular peritonitis by sunlight.

It has been demonstrated by Finsen that the pustulation of smallpox is due to the stimulation of the secondary streptococcic infection by the actinic rays. In the analogy which seems to exist between smallpox and general peritonitis, Clinton suggests that such cases should be operated upon in operating room or amphitheatre, from which the chemical frequencies of light were excluded by the use of red glass globes enclosing the electric lamp bulb. This suggestion has not to the author's knowledge been acted upon by any one. It would be interesting to utilize the suggestion in the surgical ward of some hospital where a sufficient number of cases could be so treated as to make the observation conclusive.

The Results of the Red Light Treatment in Smallpox Dependent upon Careful Technique.—The results obtained by the red light treatment of smallpox depend very largely, in fact, almost entirely, upon the thoroughness with which it is carried out. Even a trace of daylight is sufficient to unfavorably influence the result. In the early history of the method control tests were made showing that if smallpox patients were exposed to daylight after beginning the red light treatment, they invariably suffered suppuration and scarring.

The inflamed skin is as sensitive to the chemical frequencies as a photographic plate upon which radiant and oscillating energy meet cessation, for the waves in doing their work on particles of silver leave their record and come to rest. Just so upon the acutely inflamed skin, save that in doing their work, i.e., dilating capillaries producing hyperæmia and more acute inflammation even, they intensify

suppurative processes, and from the cosmetic point of view at least, in this condition do very great damage.

In arranging rooms or pavilions for the treatment of smallpox every window and opening must contain red glass or be covered with red curtains, and the same care must be taken as by the photographer in guarding his dark room. Such a room when arranged should be examined spectroscopically in order to know beyond a question that all but the red frequencies are excluded. In ordinary cases a clear red light is found to be sufficient to prevent scarring, but in very bad cases, however, there is need of a deep red light.

The Classic Measure of Painting the Face with Silver Nitrate or Smearing with Fats Valuable by Exclusion of Chemical Frequencies Most Extensively Active.—The measures which for many years have been found to secure the best results in smallpox—so far as the skin lesions are concerned, have no doubt been valuable by excluding to a certain extent the chemical frequencies, and thereby protecting the skin. In the painting of the face with nitrate of silver, for example, the silver salts served for the fixation of the chemical frequencies, preventing any further work upon their part. The smearing of the face with fatty substances may be explained in the same way, as Hartley and Huntington,[1] by their experiments showed that the normal fatty acids have a stronger absorptive power for the refractive rays of the ultra-violet region than the corresponding alcohols, and that increase in this absorptive power in this part of the spectrum is correlated with increase in the number of CH_2 groups in the molecule of the homologous alcohols and acids.

Still further investigations, involving a consideration of the relationship between the absorption spectra of carbon compounds and their molecular structure, established the fact that the fatty acids absorb those rays to a greater extent than do the corresponding alcohols. Iodine also used for the same purpose should be less effectual, as the vapor of iodine

[1]Landauer, p. 182.

which transmits the red, transmits the blue also, retarding the red even more than the blue.

In the author's experience with scarlet fever the best results have been obtained where the skin of the entire body has been protected with a carbolated glycerin. The glycerin must have served to protect the skin from the chemical light energy.

Red Light in Other Skin Diseases.—Winternitz[1] is authority for the statement that red light acts favorably in various skin diseases, having used it in such a way as to avoid heat and its resultant sudatory action. By covering up with red materials the parts of the body exposed to the sun, he diminished hyperæmias of the skin and cured eczema. The action obtained was doubtless due to the absence of the chemical activities, not to any specific action of the red frequencies just as in the treatment of smallpox and the exanthemata. He also brought about distinct improvement in cases of chronic rheumatic affections of the joints, hands and feet in the same manner.

Freund[2] entertains the opinion that long exposures of diffused red light favorably influences localized skin conditions, as acne vulgaris, ulcers of the legs, etc. The author has found, however, that acne vulgaris is favorably influenced by exposure to the chemical frequencies of light, and believes in these conditions, as well as similar ones, that the chemical frequencies concentrated and localized are preferably indicated.

In 1887, Th. Veiel[3] cured a violently and persistently recurring eczema solare in the case of a lady by directing the use of red silk veils. This seems to have been the first experiment on a scientific basis with colored light.

Unna,[4] Wolters[5] and Berliner[6] reported similarly good

[1]22 offentl. Vers d. balneol. Gesellsch., Berlin, May 7-12, 1901.
[2]Freund: Radiotherapy.
[3]Vierteljahrschr. f. Derm. und Syph., 1897, p. 1113.
[4]Monatsh. f. prakt. Derm., 1885, Vol. IV., p. 277.
[5]Ergänzungsb. z. Archiv. f. Derm. und Syph., 1892, I. p. 187.
[6]Ibid., 1890, Vol. XI., Nos. 10 and 11.

results in 1892. Instead of the red light filters Unna and Berliner used yellow (colored with curcuma) masks and veils and windows.

There are many observations pointing to the active part played by the longer, slower and less refrangible frequencies of light. These have been considered at some length in connection with the physiological action of light.

The physical fact remains that they have a stronger chemical effect upon certain substances than the shorter, higher and more refrangible frequencies. These are instanced upon page 306.

There is also a certain antagonism between the actions of the energy of these different parts of the spectrum. Certain effects of the blue and violet frequencies are neutralized by the red frequencies. It was observed by Herschel[1] as long ago as 1830 that the energy of the red region produced an opposite effect from that of the blue upon certain photographic papers. The so-called negative effect of certain light rays has been very precisely described by Fizeau[2] and Foucault.[3] In 1847 Claudet[4] demonstrated that the energy of the red and yellow regions served to check the action of the others, especially the energy of the blue on bromid, iodid or chlorid of silver. If it had already taken place it was reversed upon exposure to the red and yellow. He observed later that red and yellow light always acted negatively or destructively on bromo-iodid or bromo-chlorid plates. On iodid of silver plates they sometimes acted negatively, and sometimes the same way as blue.

Claudet studied the negative action of the energy of the single frequencies. He found that in order to reverse the action of white light that has acted for the time unit 1, 50 units of red light were required, 15 of orange and 18 of yellow.

[1]Quoted by Freund.
[2]Compt. Rend., Vol. XXIII., p. 679.
[3]Philosoph. Transactions, 1847.
[4]Philosophical Magazine, Vol. XXXII., p. 199.

The previous action of light on silver bromid may be neutralized by each part of the spectrum, from red up to violet. This was investigated by Waterhouse.[1]

Additional experiments with photographic preparations indicate that the opposed action of the red and violet energy is by no means proved. On the other hand, evidence points to a concerted action of the energy of the two ends of the spectrum.

That the red frequencies are of value in relation to therapeutics as well as in their physiological relation does not admit of question. The nature of the action of these frequencies is not yet well established, although considerable experimental work points to an action upon the sensory cortex. This has been considered at length under the physiological action of light.

The Energy of Red Light in the Treatment of Neurasthenia.—The important modifications which occur in the nervous system by the action of colored light rays or decomposed light, render it a valuable agent in combating neurasthenic conditions. Lille[2] believes that the red rays are to be preferred because of their greater penetrative power and their regulatory action upon the circulation.

In all hyperæsthetic conditions of the neurasthenic subject the effect of the long and slow frequencies of the red region are not only anodyne, but they have a beneficial effect on the general tone of the patient, with an increase in appetite and a general regulation of digestion and nutrition. Notwithstanding their great sensibility, neurasthenic patients bear treatment with red light without difficulty.

In the author's experience a complex of all the frequencies of light energy has been used in neurasthenic patients and with good results. If the results are better by the exclusion of all above the red it must be because the vibrations of the red frequencies are very long and slow. Theoretically it seems possible that the short and high frequency vibrations

[1]Proceedings of the Royal Society, London, XXIV., p. 186.
[2]La Semaine Medicale, April 25, 1902.

may act to still further irritate and exhaust the nerves which are already in a condition of exhaustion. The author believes that if a difference is made in the use of light energy in these cases, that the indications for the red frequencies of light is in those neurasthenics who have suffered a more or less complete exhaustion of the supreme nerve centre, the brain, and who in consequence are very much depressed, not only physically but mentally as well. In this connection the reader is referred to the chapter on physiological action and the case of the neurasthenic patient instanced there, with the intense craving for red fabrics and clothing. In that case there was profound anæmia of long standing and a severe exhaustion of the centres of the brain, motor and vaso-motor, sensory and intellectual.

The Possible Influence of (1) the Use and (2) the Exclusion of the Chemical Frequencies of Light Energy in the Treatment of the Psychoses.—The use of the energy of the red region of the spectrum as a therapeutic measure in melancholia has been referred to in discussing the physiological action of light and of energy of single frequencies or groups of frequencies as in the blue violet. There is certain clinical evidence pointing to more than a possible value which is supported by physiological action. An expenditure of the different frequencies or wave lengths as represented by the different colors of the spectrum must result in a different degree at least if not kind of work done in the living organism. This statement is true on physical grounds, and as has been stated is supported by some clinical evidence. To determine beyond question what place the use of exclusion of different degrees of light energy, as evidenced by the colors, has in the treatment of disease, especially nerve and mental, requires skilful, earnest, patient investigation on the part of scientific physicians. Psychopathic wards of hospitals offer an excellent opportunity for such a study, but it should not be undertaken as a fad but as a sober scientific investigation to which should be brought the physicist's training and the physician's skill. The author makes this suggestion with

no thought of supplanting any and every known therapy proven to be valuable in this class of cases, but simply with the hope that the method may either be completely refuted or else placed on a scientific basis and in its proper place in the therapy of nerve and mental diseases.

A somewhat extensive experience in the medical care of the insane, demonstrated the utter futility of all known methods of calming maniacal patients, unless heavily drugged, or of stimulating melancholiacs whose depression was so profound as to render life almost impossible to them, and a weight of woe to those who cared for them. Since the author's insight into the physics of light energy and its physiological action and experience in its therapeutic applications in a wide range of morbid conditions, including nerve pathologies, the hope has been inspired that concerted scientific effort might be made which would serve either to refute observed facts or if there is a grain of truth to determine wherein it lies. There is recalled a certain class of manias, in young hysterical subjects whose propensities for wilful, noisy and destructive conduct rendered them exceedingly difficult to care for and control, for whom theoretically at least seclusion in a blue room would have served as a quieting means. This without drugging or mechanical restraint, both of which were always avoided to the greatest extent possible by the author in the medical care of the insane.

In this connection the following statement made to the author by a Russian physician formerly a resident of Russia, but now of this country, cannot fail to be of interest and may serve still further to stimulate investigation, viz., that one of the methods used in the prisons occupied by prisoners whose socialistic tendencies had resulted in their arrest, exile and imprisonment, was to confine these prisoners, especially if alert and intelligent, in rooms from which all light energy below the blue is excluded for prolonged periods of time. The result is not only depressing so far as the spirit goes but is benumbing to the mental faculties, rendering the facile use

of the intellectual faculties an absolute impossibility. In this way these subjects are rendered harmless to the government, as well as unfitted to cope with the problems of life.

In the absence of the energy of light as a whole, bodily deformities, intellectual deterioration, crime and disease are found manifested in a higher state than in its presence. When the vital stimulus of light is withdrawn a material as well as a moral and a mental etiolation occurs.

CHAPTER XVI.

The Concentrated Invisible Chemical Frequencies of the Spectrum or Ultra-Violet Rays. Mechanisms, Spark Condenser Lamps Excited by Alternating Currents, High Frequency Coils or Static Machines, Methods of Use and Therapeutic Indications.

Ultra-Violet Light Energy.

By ultra-violet light is understood transverse vibrations of the luminiferous ether having a wave length smaller than .00004 cm.

These are very short light vibrations of very great frequency and invisible to the eye as light. The smallest wave length measured is .00001 cm. which is one-fourth of the length of the shortest wave length below the ultra-violet region.

The shortest wave length of which there is a photographic record is λ 162 $\mu\mu$. This was made by Victor Schumann, of Leipzig, who also secured a photographic record of hydrogen lines about λ 100 $\mu\mu$.

The ultra-violet rays are of intense chemical activity, and while sunlight at its source is rich in the very short and high frequency vibrations, constituting the ultra-violet region, but few if any of them reach the earth. They are absorbed by the atmosphere in transit from the sun, and the maximum chemical activity of the solar spectrum at the surface of the earth is found to be at wave length .00004, or just below the ultra-violet region. The ultra-violet sun spectrum is enormously bright at high altitudes, because there is not the same distance of atmosphere through which

the rays have to pass, and by which they are absorbed in attempting to pass.

The Ultra-Violet Spectrum of the Electric Arc.—The ultra-violet region from the electric arc is from six to eight times as long as in the visible spectrum. This was obtained by Stokes[1] through quartz. In comparison the ultra-violet region from sunlight is very short.

Means of Studying and Utilizing the Ultra-Violet Spectrum.—Stokes recommends quartz for the purpose of studying or utilizing the ultra-violet frequencies, but Schumann found that it absorbed the wave lengths below 200 $\mu\mu$. He was, therefore, obliged to substitute for it fluorspar. With this he made his observation on the shortest wave lengths known, as referred to above, the spectrograph being made vacuous.[2] Grating spectroscopes are especially adapted for determining the presence of ultra-violet frequencies if the presence of glass be avoided. Photography supersedes all other methods of investigating the ultra-violet frequencies; but as those below 200 $\mu\mu$ are absorbed by gelatin, Schumann used plates without a gelatin film.

Maximum Energy and Maximum Chemical Energy of the Solar Spectrum.—The wave lengths constituting the visible spectrum are from .00004 cm. at violet to .00007 cm. at red. But while the maximum chemical activity of the solar spectrum is at wave length .00004, the maximum energy of the solar spectrum is at wave length .00008, or twice that of the maximum chemical activity.

By this maximum energy is understood the radiant energies of all the frequencies of sunlight from those of longest length and greatest amplitude to those of shortest length and the least amplitude in the swing of its oscillating corpuscles.

Influence of Temperature upon the Ultra-Violet Region. —The length of the solar spectrum beyond the violet is still unknown. In the ultra-violet region the solar spectrum does

[1]Ganot's Physics.
[2]Landauer: Spectrum Analysis.

not extend beyond about 300 $\mu\mu$. As the temperature rises spectra tend to develop in the ultra-violet; hence on account of the extremely high temperature of the sun, a considerable portion of its spectrum must necessarily escape observation. The physical experimenter is, however, constantly endeavoring to find means for the development of these intensely chemical frequencies from artificial sources.

In view of all that is known of the action of ultra-violet frequencies, not only of the rhythmic flow of the oscillating light corpuscles of that region but of that single, solitary, infrequent impulse, similar, as it stands alone to the ultra-violet, the X ray, it requires little effort to believe that there is a region beyond the ultra-violet, as it is known and used to-day, capable of the most intense and violent physiological action.

Ultra-Violet Gradually Diminish Until they Become Roentgen Waves.—The lengths of the ultra-violet frequencies are known to be exceedingly short, and it is highly probable that they become still shorter until they become Roentgen waves. These latter are waves or solitary pulses in the ether. They have been likened to one single solitary shell, and owing to extreme thinness of the shell, they have extraordinary penetrative power. They have also been likened to a falling brickbat, coming once in a thousand years or so, as compared with the frequency and rhythm of ultra-violet rays. They travel in absolute straight lines, nor are they refracted or deflected by any substance, nor can they be bent aside. They may be stopped and be made to pass shadows, the sharpness of which depend only on the smallness of the radiant point; but unlike the waves of light, they cannot be bent. Lenses, prisms, magnets, electric charges, have no power over them. Hence they may be passed through all manner of substances, travelling through in a straight line path, and thus they throw the sharpest possible shadow if their source is a point.[1]

[1]Sir Oliver Lodge: Archives of the Roentgen Ray and Other Allied Phenomena, April, 1904.

Velocity and Intensity Reduced in the Ultra-Violet in Transmission through Glass.—So far as is known the velocity of light is the same for all frequencies. In travelling through the ether that fills the interatomic and intermolecular spaces of transparent substances, such as glass, the velocity is not only reduced, but the intensity of the vibration is also reduced, differently for different frequencies; high frequencies being generally more reduced than low frequencies. It is because of this physical law that the use of screens of colored, or lenses of clear glass, are to be avoided in the arrangement of any source of ultra-violet radiations for therapeutic work. The passage of the high frequency waves are thereby cut off to such an extent as to greatly reduce the beneficial results obtained. On the other hand, the high frequency waves readily pass through quartz without much absorption to wave lengths up to 200 $\mu\mu$; in other words, it is transparent to the pure ultra-violet rays. In this physical fact is to be found the reason why vacuum tubes of glass, however brilliantly they glow and hypnotize a credulous public, and even the profession, are absolutely devoid of true ultra-violet radiations.

The velocity of light is, to be exact, 186,400 miles a second or one foot in about the thousand millionth part of a second. But it does not travel at the same speed through water as through air, only three-fourths as fast or 138,000 miles per second. This would be but nine inches in a thousand millionth part of a second as against one foot. Through common glass it goes still slower. Some kinds of glass, that is, glass differing in composition, cause a greater retardation than other kinds, but on an average the retardation of light waves is such that they travel only about two-thirds as fast as in air. While a given source of light was travelling one foot through the air it would travel only eight inches through glass.[1]

Here again are the two physical reasons why light for

[1]Thomson, Silvanus P.: Light Visible and Invisible, p. 33.

therapeutic work where the intense chemical activities are required, should not pass through the medium of water or glass. The change in velocity is the result of the inability of the short high frequencies of oscillating light corpuscles or ultra-violet light to pass (1) through glass and (2) the absorption of these frequencies in passing through water.

Theoretical Completion of the Ultra-Violet Spectrum.—From the amount of dispersion of light, that is, its separation or analysis into its constituent frequencies or wave lengths by reason of the heterogeneity of the constitution of matter, an estimate of the size of the molecules can be made. It has been shown by Helmholtz, Stokes, Kelvin and other great mathematical physicists, that if wave lengths existed still smaller than the molecules they would tend to be treated all alike, just as they are when very much bigger than molecules.

Therefore, says Lodge,[1] a theoretical completion of the ultra-violet spectrum involves a complete folding of the spectrum back upon itself as it were, the higher frequencies being less and less bent, that is, refracted, and finishing off by rays that would not be bent at all, but, as von Helmholtz said, would proceed unrefracted and comparatively unabsorbed by ordinary opaque matter; that is to say, infinitely short waves would go on in straight lines and be very penetrating. This theory is beautifully illustrated by the X ray. They are not a continuous rhythmic chain of waves like light; they are ether pulses, but they are discontinuous, series of single pulses in enormous numbers not like an organ peal but like a constant succession of whip cracks from a million energetic drivers.

Somewhat the same sort of disturbances, though on a larger scale, is employed for ordinary wireless telegraphy.

The whole of this theoretical spectrum is not to be experienced from any known source. It is possible that the sun may emit it, but sunlight is unknown save as it is modi-

[1]Sir Oliver Lodge: Archives of the Roentgen Ray.

fied by the atmosphere, no matter what the altitude, although much less modified at high altitudes. This not only cuts down the ultra-violet energy, which is absorbed but the X ray energy, if it exists.

Ultra-Violet Light Energy Invisible, but Made Visible by Fluorescence.—While as has been stated the visible spectrum lies between wave lengths 400 $\mu\mu$ and 760 $\mu\mu$ if the longer waves are eliminated by suitable media, wave lengths far beyond 400 $\mu\mu$ are seen. But instead of the 400 millions of millions and 800 millions of millions presumed to be necessary to affect the retina the frequency of the ultra-violet goes up to 1,600 million millions per second. These are the highest frequency oscillations known and correspond to a thousand million million electric pulsations per second. Ultra-violet frequencies are, however, made visible by their action on fluorescent substances. This phenomenon depends upon the ability of certain substances to absorb energy of radiation at one wave length and to emit it at another. The phenomenon of fluorescence is not a property of the ultra-violet region alone. In this connection, however, it is of concern only in relation to ultra-violet frequencies. By the introduction of a fluorescent object, such as a plate of uranium glass, into the eye-piece of a prism spectroscope, ultra-violet frequencies of the source of light energy at once become visible.[1]

The same purpose was accomplished by H. von Helmholtz,[2] by placing a thin film of quinin sulphate in the telescope at the spot where the objective forms a true image of the spectrum. For the investigation of the ultra-violet frequencies, special instruments, with lenses and prisms of quartz are required, as they are absorbed by glass.

Langley[3] says of the ultra-violet spectrum in connection with a description of his infra-red or thermal spectrum that "it would take a hundred feet of map to depict it on the

[1]Soret quoted by Landauer, Spectrum Analysis.
[2]Optique Physiologie, p. 352. Quoted by Landauer.
[3]Langley, p. 684, Smithsonian Report, 1900.

prismatic scale, though this is caused by but a small fraction of the sun's energy, so monstrous is the exaggeration due to the dispersion of the prism. It really contains much less than the one-hundredth part of the total solar energy which exists, the visible spectrum containing perhaps one-fifth the energy of the sun."

In connection with this region interesting alike to the physicist and the medical man there is open here a new world to be explored, for all discoveries are "Pointing the way to future knowledge of the connection of terrestrial life with that physical creator of all life, the Sun."

Transmission of Ultra-Violet Rays.—While it has been pointed out that the air, glass, water and, for the shorter frequencies of this region, quartz even, are more or less opaque to ultra-violet rays, there are many other substances which have varying degrees of transparency or opacity for ultra-violet rays. The atmosphere is regarded as equivalent to thirty inches of mercury or four and one-half feet of lead in relation to ultra-violet energy. It is therefore very opaque to these frequencies.

There are four classes of such substances:

(a) Complete transparency throughout ultra-violet region.

(b) Opaque throughout ultra-violet region.

(c) Opacity increases with decrease of wave length.

(d) Exhibiting absorption bands.

(a) Complete transparency throughout the ultra-violet region: Potassium chlorid, sodium chlorid, strontium chlorid, thallium chlorid, indium chlorid, ammonia-aluminum sulphate, potassio-aluminum sulphate, rock salt, quartz, gypsum, solid alum, fluorspar and calcite (plate cut perpendicularly to optic axis).

(b) Opaque throughout ultra-violet region: window glass from wave length .0000325 m., plate glass and flint glass wave length .0000325 m., black glass, red glass, uranium glass, blue tourmaline, green tourmaline, chlorophyll in alcohol, alcoholic solution of stramonium salt.

(c) Opacity increases with decrease of wave length: white mica.

(d) Exhibiting absorption bands: iodin in CS_2, uranium nitrate.

At a meeting of the American Physical Society in December, 1902, Professor R. W. Wood of the Johns Hopkins University, described and exhibited a screen which was transparent to ultra-violet rays. This was made by combining a gelatin film containing nitroso-dimethyl-anilin with copper oxid and cobalt glass. While being opaque to the rest of the spectrum such a screen is very useful in photographing the ultra-violet spectra since it enables the overlapping spectra of other orders to be eliminated. The author showed an interesting lecture experiment in which the rays of the lantern, after passing through such a screen, were concentrated to an invisible focus, where a suitable fluorescent substance was excited. This should furnish an invaluable means of sifting out other frequencies and studying the action of ultra-violet frequencies alone in therapeutic work as well as physical experiment.

Absorption in the Ultra-Violet.—Sunlight contains much ultra-violet at the top of mountains and some wherever the air is clear as at sea: clean water vapor not being very opaque to it. But the thinnest vail of smoke or other foreign material in the air cuts off the whole of the ultra-violet region, letting the heat rays through undisturbed, however, in fact, even helping to entrap them. For these reasons sunlight in or near towns has very little chemical activity. There is enough to affect sensitive photographic plates, but not enough for bleaching or other chemical purposes, nor is there sufficient for bronzing the skin or the destruction of bacteria. In the country, on the other hand, the ultra-violet residue which reaches the earth's surface, is entirely within physiological bounds and produces effects which, as a rule, are attributed to ozone.

According to Cornu[1] the absorption of the ultra-violet

[1]Landauer: Spectrum Analysis, p. 202.

region is not caused by the varying constituents of the atmosphere, such as water, vapor, or dust, but essentially by nitrogen and oxygen. He has suggested a formula for the calculation of the solar spectrum absorbed by the column of air which the light traverses; according to this a thickness of 663 metres causes a diminution of 10 Å at the ultra-violet end.

The investigations of Hartly and Huntington[1] showed that the normal fatty acids have a stronger absorptive power for the refractive rays of the ultra-violet region than the coresponding alcohols, and that increase in absorptive power in this part of the spectrum is correlated with increase in the number of CH_2 group in the molecule of the homologous alcohols and acids.

In the case of the alcohol and the acids the absorption increases as the content of carbon in the compound increases. A simple linkage of carbon and nitrogen is sufficient to produce characteristic absorption of the ultra-violet rays.

Hartly also examined the spectrum of carbo-hydrates and albuminoids, investigating the physical combination of these compounds with the soluble ferments. The spectra of egg albumen and casein exhibit certain bands in common which are absent in the spectra of malt-diastase, yeast inverstase, gelatin, starch, glucose and saccharose, solutions of which are particularly transparent to the violet and ultra-violet rays. The albumens are thus shown to differ considerably from the ferments in constitution, and this accords with the difference in behavior shown by the compounds toward the carbo-hydrates. Other substances for example, benzene and its hydroxyl, carboxyl, and amido derivatives, have a light absorption power for the ultra-violet rays, and in thin layers exhibit strong absorption bands.

Absorption in the Ultra-Violet by Quartz Media.—Ultra-violet λ 350 $\mu\mu$ are absorbed to a very considerable extent, and those of about λ 300 $\mu\mu$ completely through the media

[1]Ibid.

of glass. The author wishes to make this statement so emphatic that no question can arise in the mind of the student as to the phenomena presented by vacuum tubes of glass. Nor does the arrangement of the mechanism used to produce these phenomena as a possible source of ultra-violet frequencies need to concern him so long as tubes of glass are used. Ultra-violet frequencies may be generated thereby, but so long as they are within the glass they are of no avail for therapeutic purposes.

In defiance of the well-known physical law the statement is constantly made by those interested in the manufacture of vacuum tubes for medical work, that vacuum tubes of glass, unipolar or bipolar, are an efficient source of ultra-violet radiations.

Willemite as a Test for Ultra-Violet, Cathode and X Rays, also for High Frequency Currents.—In this connection it may be stated that willemite is commonly used by physicians in testing the light values of different forms of light apparatus. It fluoresces under the influence of X rays, cathode rays and ultra-violet rays. It is believed by physicists that it will fluoresce under other conditions, high frequency vibrations, for example.[1] It is only considered a conclusive test for the existence of ultra-violet rays when used to locate the spectrum of a source of light which has been produced by means of grating, or by quartz lenses and prisms.

Glass Transparent to Wave Lengths Longer than 30 Microcentimetres.—The fact should not be lost sight of that glass is transparent to longer wave lengths, and that these frequencies possess to a greater or less extent the properties of the higher frequencies. This is shown in photography, and is also a matter of daily observation in the therapeutic uses of light. Glass is transparent to the blue-violet or longer wave lengths, and they are valuable in therapeutics, but so far as proven, not as valuable as the ultra-violet either in bactericidal power or in ability to excite tissue reaction.

[1]See Fluorescent Action of High Frequency Currents under Vacuum Tube Discharges, Chap. XVII.

They are, however, capable of greater penetration within the tissues.

In Therapeutics a Complex of Wave Lengths, Blue Indigo, Violet and Ultra-Violet Most Valuable.—But while these invisible ultra-violet frequencies are of great intrinsic value it must never be lost sight of for one moment that the complex of wave lengths blue, indigo, violet and ultra-violet is infinitely more valuable.

Ultra-violet rays have the following properties:

(a) Chemical changes on silver salts, etc.

(b) The production of fluorescence.

(c) Electrify positively metals, especially polished zinc.

(d) Decrease necessary break down voltage of an air-gap on which they shine.

(e) Discharge negatively charged bodies on which they shine. Of these phenomena, (c), (d), and (e) are considered to be due to ionization of the air; (b) may be due to mechanical impact disturbances or to resulting rise of temperature; while (a) may be due to any of these causes.

Chemical Changes Induced by Ultra-Violet Energy.—Under the chemical changes induced by ultra-violet frequencies there is not only the well-known action on silver salts, but their physiological effects upon animal and vegetable life, which are fully considered under their appropriate headings. Bronzing of the skin is due to the ultra-violet light which the air does not stop, and which is reflected from snow or ice as well as received directly from the sun and sky and clouds.

Affinity of Ultra-Violet Frequencies for Oxygen.—These frequencies have a great affinity for oxygen, and it has been pointed out by Sir Oliver Lodge[1] recently, that if the same conditions could be produced in the interior of the body, pelvic tissues, for example, that exist on the exterior, i.e., the presence of free oxygen, that ultra-violet rays, X ray and radium would necessarily be more effectual in their action.

[1]Lodge, loc. cit.

Were it not for the free oxygen on the superficies of the body, the intense oxidizing action as evidenced by the blistering of the skin and bactericidal effect, would not take place. Were it possible to introduce it deep within the tissues the same action would take place there.

Special Action of Ultra-Violet Frequencies upon Skin of Man, Tissues of Lower Animals and Plants.—Ultra-violet frequencies not only have a special action upon the skin of higher animals, but upon the entire tissues of the lower animals and plants. High up where the air is rarefied the action upon the skin is so strong as to produce intense erythema, unless time is given for the development of pigment cells.

Influence of Screens of Glass.—A screen of glass will effectually prevent this action as it will absorb the ultra-violet frequencies. Under the action of electric light upon plants it is pointed out that a naked arc lamp will wither the leaves of plants by reason of its intense chemical energy in the ultra-violet region. By the interposition of glass they are shut off and the transmitted frequencies are the usefully active chlorophyll-stimulating rays. It takes the place in relation to the arc that the atmosphere does in relation to the original energy emitted by the sun. This action can be very quickly shown by permitting the energy of the unprotected arc to fall upon one-half of a leaf, and through a glass screen on the other half, the unprotected leaf will turn brown and the other remain green.

The Electroscope the Best Test for Ultra-Violet Rays.—The best test for determining the presence of certain kinds of radiation is the electroscope. An electroscope is an apparatus (1) for detecting the presence of electrification, and (2) for detecting differences of potential. With it the presence or absence of ultra-violet frequencies can be determined. When it is placed in ordinary light the electrically charged leaf of the electroscope, no matter of what metal made, will not leak; but when connected to a piece of clean zinc, it will leak rapidly when ultra-violet rays fall upon it.

Fig. 33 shows an electroscope with the leaves diverging and ending externally in a polished zinc ball. When exposed to the ultra-violet rays, the electroscope at once begins to be discharged. It is the same part of the ultra-violet frequencies, which are active for therapeutic purposes, which discharge the electroscope. If a piece of glass intervene between the electroscope and source of ultra-violet energy no action whatever takes place, there is no leakage of the charged body, but remove the glass and it is quickly discharged, or interpose a piece of quartz and it is discharged

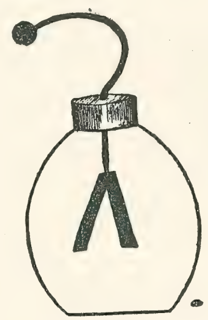

Fig. 33.—Electroscope with polished zinc ball, for showing the effect of ultra-violet rays.[1]

just as quickly. The ultra-violet frequencies from the condenser spark will discharge an electroscope in five seconds as against twelve seconds from an arc light. This shows the preponderance of these frequencies in spark charges. The breaking down of the electrical resistance of the air is due to the frequencies of very short wave length. Ultra-violet rays also produce nuclei for cloud condensation in moist air. Professor Lenard has come to the conclusion that wave lengths λ 1,600 to λ 1,900 are active in this regard.

The Nature of the Action of Ultra-Violet Energy in Discharging an Electroscope.—In the leakage of a regularly charged electroscope, with a recently cleaned zinc terminal, from the action of ultra-violet energy, atoms which have ac-

[1]Sir Oliver Lodge: The Archives of the Roentgen Ray.

quired an extra or supernumerary electron will, when jostled by ultra-violet waves, that is, the vibrational activity of oscillating corpuscles not very different from the periods of vibration natural to the atoms themselves, fling the extra electron off.[1] This action can be immediately stopped by the intervention of a screen of glass, as visible light has no such effect. If the charge is positive instead of negative the action is also nearly suspended. If the zinc surface is dirty it is much slower still. There is a slight residual action on most surfaces, as those of rocks and leaves, for example, whether they be charged positively or negatively. This is a part of the cause of atmospheric electricity, but it is a small effect compared with the rapid leakage from negatively charged, recently cut or scratched surfaces of metal.

Difference Between Action of Ultra-Violet and X Ray Energy in Discharging Electroscopes.—In instituting a comparison between ultra-violet and X ray energy, the latter will be found to cause violent leaking of the electroscope, no matter whether it is positively or negatively charged, and no matter what its surface may be. The X rays do not act upon the surface but upon the air. On the air they act chemically, ionizing, breaking up its molecules into charged atoms, rendering it, therefore, a conductor or electrolyte, in which all charged bodies must rapidly lose their charge. These effects persist for a time after the X rays have ceased, until the dissociated atoms have had time to recombine in the molecules and the air resume its normal condition. This property of "ionization" must be the most important therapeutic property of the X ray. Light has only the ability to act on unstable chemical compounds while X rays seem able to shake asunder even stable molecules, the molecules of ordinary substances. For example, they can produce a violet color in manganese glass and can color various salts. They strongly shake asunder the binary molecules of atmospheric oxygen and nitrogen, dissociating them into

[1]Lodge, loc. cit.

free ions, which may subsequently combine into oxides of nitrogen and ozone as well as their original simpler molecules. Radium rays which have penetrated glass and mica can oxidize iodoform, turning a solution of it in chloroform deep brown by these penetrable rays.[1]

Lodge,[2] whose views on the differences and similarities between the action of X rays and ultra-violet light energy have been quoted, further states, that as regard the cells of the body, the former probably act most on active cells, where changes are occurring, and that he should expect them to act, therefore, more on the dermis than on the epidermis. He concludes that it would be odd if they did not act upon the hæmoglobin. That they have such an action, the author believes, and that this action, a deleterious one ultimately, is the cause of the ghastly chlorotic coloring of those exposed for long periods to the action of X ray energy.

Just upon going to press, the author finds that this opinion hazarded by Lodge from purely physical considerations, and which was endorsed by the author from physical considerations, supplemented by clinical observation, has been established by experimental observation.

Darier, Unna, Jutassy and Minich among others, by microscopic examinations of the exposed cutis, showed the correctness of Lodge's hypothesis as to the action of this energy upon the dermis. The experimental researches of H. Heinecke, as well as the clinical observations of M. Mauté, have established the correctness of the hypothesis as to the action of the X ray on the hæmoglobin.

Mauté has carefully studied the cellular composition of the blood in cases treated by radiotherapy (exposure 2 to 6 minutes), and has noticed that during the hour following the exposure, there is an appreciable modification of the cellular equilibrium of the blood, which is attended by an increase in the number of both the white and colored corpuscles, the percentage of polynuclear and large and small

[1]Hardy and Wilcox, "Proc. Royal Soc.," Vol. LXXII., p. 202.
[2]Lodge, loc. cit.

mononuclear cells being greater than normal. The leucocytosis thus induced is analogous to that set up by revulsive applications (vesicants, cold, etc.), or that which attends digestion. Heinecke's experiments, on the other hand, go to prove that the lymphoid structures of the body are even more susceptible to the X rays than the cutis. In small animals exposed to the rays for some hours the spleen showed an excessive increase in pigment, a disappearance of the follicles and a general destruction of the splenic pulp. The follicular changes were noticed soon after the exposure to the rays, and were completed in 24 hours. The nuclei of the lymphocytes in the follicles are first disintegrated, their remnants being removed by phagocytes, which in turn disappear from the spleen when the destruction of the follicles is complete. It was found that an exposure of 15 minutes is sufficient to start these changes in rabbits and small dogs. In the case of short exposures the amount of destruction is limited and repair can undoubtedly take place.[1]

Ultra-Violet Frequencies.

(1) Can be reflected, refracted and polarized.

(2) Will not traverse bodies that are perfectly pervious to luminous frequencies, for example, glass.

(3) Will not influence the deeper tissues, nor even the superficial ones, unless they are deprived of their blood, i.e., dehæmatized. (It has been shown that they penetrate a frog's web even when the blood is circulating and the conclusion is reached that they pierce the epidermis and are able to reach the lower layers of the skin.)

(4) Will be stopped by a single leaf of paper.

(5) Will rapidly destroy the vitality of bacteria.

(6) Will produce inflammatory action on the skin.

(7) Will discharge an electroscope if electrified negatively, but not positively.

(8) Will excite green fluorescence in willemite, and induce blue phosphorescence in polysulphide of calcium.

[1]Editorial, Medical Electrology and Radiology, July, 1904.

(9) Rock salt is transparent to ultra-violet frequencies.

Photo Electric Effects of Ultra-Violet Light Energy.—In 1887, it was discovered by Hertz[1] that the incidence of the ultra-violet light on a spark gap facilitated the passage of the spark. Since then experimental work at the hands of physicists has established the fact that a newly cleaned surface of zinc, if charged with negative electricity, will rapidly lose its charge upon exposure of its surface to ultra-violet light. On the other hand, if uncharged to begin with, it will on exposure to ultra-violet light rapidly acquire a positive

Fig. 34.—Experiment showing ultra-violet rays discharging a piece of zinc. *U,* ultra-violet lamp; *Z,* zinc; *B,* wire connecting zinc with electrode E.[2]

charge, the negative electrification going out meanwhile into the gas by which the metal is surrounded.

By directing a powerful air-blast against the surface of the positively charged surface the charge will be greatly increased. This zinc surface when positively charged suffers no loss upon exposure to the air. Any light source rich in ultra-violet frequencies may be said to produce these effects, the electric arc, burning magnesium or the spark from an induction coil or static machine between zinc or cadmium terminals, the light from which is very rich in ultra-violet frequencies. Although the solar light is not rich in ultra-violet frequencies, it has been shown by the experiments of Elster and Geitel[3] that the more electro-positive metals lose negative charges even when exposed to daylight. In their power of discharging negative electricity, metals may be arranged in the following order according to the same investigators:

[1]Hertz: Electric Waves.
[2]Sir Oliver Lodge: Archives of the Roentgen Ray.
[3]J. J. Thomson: Conduction of Electricity Through Gases, p. 212.

Rubidium, potassium, alloy of potassium and sodium, sodium, lithium, magnesium, thallium, zinc. The effects of ordinary light upon copper, platinum, lead, iron, cadmium, carbon and mercury are too small to be measured. The order of the metals for this effect is the same as that of Volta's for contact electricity, the most electro-positive metals giving the largest photo-electric effects.

The action of ultra-violet light induces the discharge of negative electricity in many substances other than metals. Thomson mentions among the more active photo-electric solids, the following: Fluorspar, the various colored varieties of which vary greatly in the degree to which they possess this faculty; the sulphids of antimony, lead, arsenic, manganese, silver and tin (the sulphates do not possess this property); hydroxid of tin, iodid of lead, and many anilin dyes in the solid state. A thin surface of water over a metal will interfere with this function as water is not photo-electric. The solutions of many substances are, however, actively photo-electric. Especially is this true of the fluorescent substances, for example, eosin, fuchsin, cyanin, hydrochinon, congo red; potassium nitrate and formic acid also show this effect. On the other hand solutions of sulphate of quinin, potassium permanganate and phenol do not show this effect.

A different effect is observed in gases from the case of solids and liquids as a result of the action of light, as it is not possible in gas to get a separation of the gas that one part may become positively electrified and another negatively electrified. If a molecule of gas, when exposed to ultra-violet light, loses, as does a piece of metal, its negative electricity, then it will behave like a positive ion and the negative corpuscle it has lost will attach itself to some other molecule of the gas which will act like the negative ion.

Therefore Thomson concludes that if the same effect is produced upon the molecules and atoms of a gas, as upon a mass of metal, by the action of ultra-violet light, an ionization of the gas would follow. From every point of view this seems to be the case, and the electric arc because of its

ultra-violet frequencies acts to produce an ionization of the air. This ionization of the air of an electric arc bath for example, the author believes to be one of the therapeutic factors.

A connection also exists between the photo-electric effects and the absorption of ultra-violet light. Stoletow, quoted by Thomson, pointed out that water which does not give photo-electric effects, does not absorb many of the visible or ultra-violet rays, while photo-electric solutions, such as those of methyl green or violet which are photo-electric show strong absorption.

A more extensive investigation of the subject by Hallerachs[1] showed that all the photo-electric liquids which he tried showed strong absorption for ultra-violet light. On the other hand strong absorption was not always accompanied by photo-electric effects; thus, for example, the aqueous solution of fuchsin is photo-electric while the alcoholic solution is not, and yet more ultra-violet light is absorbed by the alcoholic than by the aqueous solution.

The photo-electric effects do not exist when the source of light is removed, Stoletow[2] having showed that the interval between its removal and the total cessation of effects was not more than 1/1000 of a second. G. C. Schmidt investigated the relation between photo-electric effects and the fluorescence and ionization of solutions but was unable to obtain a clear evidence of any intimate relation between photo-electric effects, ionization and fluorescence. Different salts and solutions examined presented widely varying results. Some seemed to show a clear relation between photo-electric effects and ionization, others not.

Metals in High Vacua when Illuminated with Ultra-Violet Light Give out Corpuscles.—Thomson's[3] and Lenard's experiments show that in high vacuum, metals when illuminated with ultra-violet light give out corpuscles, i.e., bodies

[1]J. J. Thomson: Conduction of Electricity Through Gases, p. 217.
[2]Thomson.
[3]Thomson, p. 241.

whose mass is only about 1/1000 of that of the hydrogen atom; when, however, the metal is surrounded by gas the corpuscles soon strike against the molecules, get attached to them and have to drag them along with them as they move under the action of the electric field.

Rutherford[1] found upon measurement that the velocity of the negative ions through different gases did not depend upon the nature of the metal on which the light fell, but that it did depend upon the nature of the gas through which the ion had to travel; and that the velocity through any gas of the negative ion produced by ultra-violet light, was approximately the same as that of the ion produced by Roentgen rays through the same gas.

Methods of Production of Ultra-Violet Rays.—Were it possible to utilize the sun's radiant energy before its passage through the air, a source of very great ultra-violet activity would be at command. Luckily for both animal and vegetable life this is impossible. The intense chemical action generated thereby would be disastrous. But fortunately there are artificial sources of light at command rich in ultra-violet frequencies and capable of perfect control, which can be used in therapeutic work. The value of the electric arc, with electrodes of carbon, of iron and carbon and of iron alone, requiring from 5 to 80 ampères of current, has been duly considered. From all those sources, however, the luminous output is a complex of all the frequencies of the spectrum. This is true in the following order: (1) the carbon arc; (2) the iron and carbon arc (more violet and ultra-violet); (3) the iron arc (more ultra-violet).

Ultra-Violet Energy Assumed to have been the Principal Factor in Therapeutics.—It was assumed both from experimental work and from Finsen's work with powerful electric arcs, so active chemically and especially so rich in ultra-violet frequencies, that the results obtained were largely due to the latter. Therefore there has been a constant endeavor on the part of both physicians and operators,

[1]Quoted by Thomson.

during the past few years, to devise mechanisms for use with sources of light especially rich in these rates of vibration.

To this end the iron electrode lamps which have been considered in the previous chapter were constructed. As has been seen they give a spectrum in which the violet and ultra-violet predominate.

Here it is only the purpose to speak of methods for the production of the ultra-violet frequencies, or at least as nearly pure as it is possible to have them.

At a Temperature Higher than Boiling Carbon More Ultra-Violet Energy.—A high temperature source is necessary for the production of ultra-violet energy. For it, the chief sources are the electric arc, an electric spark or a brush discharge. An artificial source of light hotter than boiling carbon will give a light richer in high frequency waves, not only of higher intrinsic energy, but of greater total energy, capable of most profound chemical action.

The Electric Spark Rich in Ultra-Violet.—In the electric spark, whether from a static machine or a high tension coil, is to be had a source very rich in these frequencies, especially when metallic terminals, such as zinc, copper, iron, cadmium, aluminum and mercury are employed. For this purpose iron is perhaps the best. It vibrates at 480 different velocities and gives a spectrum extending from λ 6678.23 Å to λ 2214.70 Å (corrected according to Rowland's tables).[1]

Especially is this true of powerful high tension coils, such as those of Tesla and Elihu Thomson. The negative terminal is particularly active in this way. The lightning discharge is also powerfully active chemically, the frequencies of the ultra-violet predominating. The light of spark discharges has been used many years by experts in photography and spectrography, in their spectroscopic and photospectrographic experiments, the intensity of which has been increased by the use of Leyden jars. The light from these sources has a powerful bactericidal effect. The first suggestion for the use of spark discharges from an induction coil as a source of light energy in therapeutic work was made by Görl.[1] At the same time Leduc,[2] in experimental work, showed the exceeding richness of the spark discharges of an influence machine in ultra-violet frequencies.

[1]Landauer: Spectrum Analysis.

He found that photographic effects were obtained surpassing in intensity those of sunlight, from the spark of an influence machine, and that the light produced an intense fluorescence on a platino-cyanid screen, without concentrating the beam, and he suggested in 1901 that it be used as a source of ultra-violet light for therapeutic work.

The use was considered by the author as early as 1899, but owing to a multitude of duties, no effort was made to put the thought into execution, and as an 80-ampère arc was in use in connection with a Finsen tube there was no need of the mechanism.

Bactericidal Effect of Spark Light.—Marshall Ward[3] and Strebel[4] have furnished proof of the powerful bactericidal effect of spark light. By his experiments Strebel showed that the spark of an induction coil at a sparking distance of 20 cm. kills all kinds of microbes at 70 to 140 cm. distance in a few minutes. If the objects were brought to the source of the light, the same result is obtained; but in a space of time which compares favorably with the arc light.

The Görl Apparatus for Spark Light from a Static Machine or Coil.—The Görl apparatus for the production of spark light consists of five aluminum balls arranged in the form of the letter S, along which, from ball to ball, the spark flashes. These are insulated, set in a hard rubber or mica, preferably the latter, base, and covered with a cap in which is placed a quartz disc.

[1]Görl. "Zurlicht Behandlung mit ultravioletten Strahlen." Muenchner Medicinische Wochenschrift, No. 19, Mai 8, 1901.

[2]Production Électrique des rayons chimiques pour les applications Médicale. Annales d'électro-biologie, March-April, 1901.

[3]Proc. of the Royal Society of London, 1904, Vol. IV., p. 472 ff.

[4]Deutsche Med. Wochenschrift, 1901, Nos. 5 and 6. Quoted by Freund.

The Strebel Spark Lamp.—The Strebel instrument for producing ultra-violet light, from an induction coil, consists of a short ebony tube, 6 cm. broad, which is closed on one side by a quartz lens, on the other by a concave mirror of magnalium metal.

The conducting wires pass through the walls of this apparatus and terminate in one or more pairs of aluminum electrodes which stand opposite to each other, a short distance apart, in front of the concave mirror. Air is forced into the capsule by means of a small bellows, which serves to keep the electrodes from becoming heated, and also to drive out the ozone and metallic vapor formed by the spark.

St. Bartholemew's Induction Coil Arc Lamp.—The Görl instrument is manufactured in London under the name of the "St. Bartholemew's Induction Coil Arc Lamp." It is also manufactured in this country, as shown in Fig. 35, and was

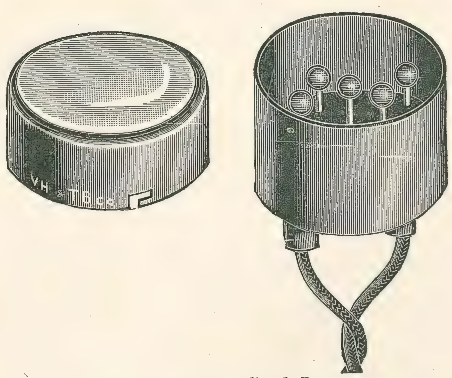

Fig. 35.—The Görl Lamp.

described by the author in an article bearing date February 7, 1903.[1] The five aluminum (iron has been used in the same apparatus as well) rods, capped with balls arranged in the form of a figure S, are set in a hard rubber base continuous with a cylinder of hard rubber (a). This is in turn filled with a plate or disc of quartz (b), for the purpose of con-

[1]Cleaves: Portable and Easily Adjustable Mechanisms for Ultra-violet Light, N. Y. Medical Record, March 27, 1903.

centrating the light, and which also serves as a compressor to render the part to be treated anæmic.

It may be used with or without the Leyden jars in circuit. The author uses it as a rule without, connecting it directly to the discharging rods of the static machine or the terminals of a high tension coil, an X ray coil, for example.

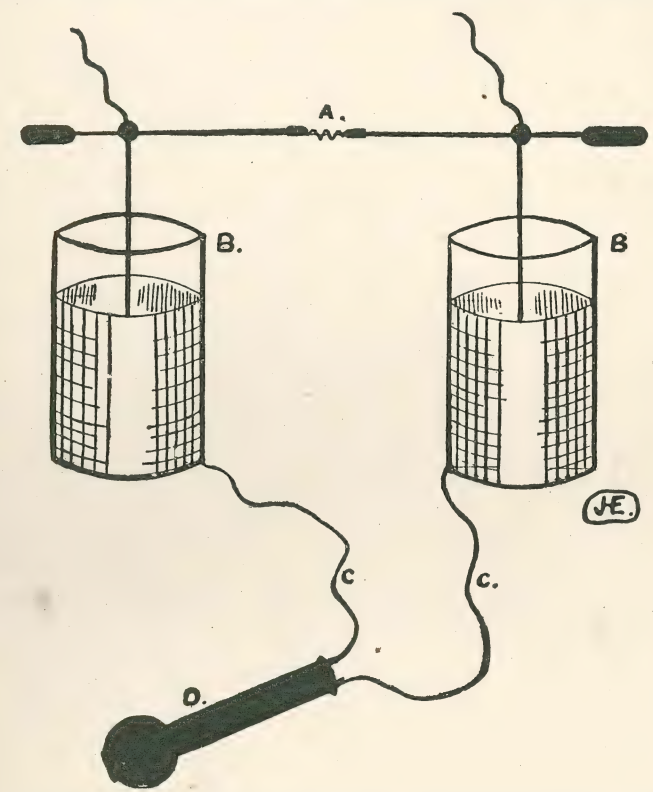

Fig. 36.—Showing ultra-violet lamp connected with the outside coatings of two Leyden jars.[1]

A similar lamp is shown in circuit with the Leyden jars in the accompanying cut.

The Piffard Induction Coil Arc Lamp.—Piffard[2] re-

[1]Sir Oliver Lodge, Archives of Roentgen Ray.
[2]Piffard: Radio-Praxis, N. Y. Med. Record, March 7, 1903.

ported a modification of the St. Bartholemew Induction Coil Arc Lamp in a paper read before the New York Academy of Medicine, February 19, 1903. The London lamp has but one spark gap as against four in the original Görl apparatus. The Piffard lamp has three spark gaps. The balls are also set in a hard rubber base, surrounded by a cylinder, and in turn fitted with a cap containing a disc of quartz. The hard rubber cylinder has about its circumference several openings for the purpose of cooling the electrodes, and freeing the air from ozone and metallic vapors. By reason of these openings it is more difficult to secure the passage of the spark in humid atmospheric conditions. The principle is the same in all.

The author's work has been done with the one shown in the cut.

A Vaginal Spark Lamp.—The author utilized the same principle in having constructed a vaginal lamp, but as it was constructed of glass, its usefulness was at once minimized, as there are present in the spark discharge very few of the frequencies of greater wave length than the ultra-violet, and the latter could not pass owing to the glass enclosing cylinder. It was noted, however, when using it in cases of cervical cancer, that upon withdrawal a chemical action was evidenced by the discoloration (oxidation) of the vaginal discharge. As this took place, however, on that part of the external surface of the glass enclosing cylinder, opposite to which the metal balls approximated very closely in the interior, it was thought to be due to the electrical discharge.

Strebel[1] has also utilized the same idea for the treatment of the accessible mucous cavities, but the cylindrical glass tubes and catheters are open to the same objection as in the author's vaginal lamp. It is possible to have a quartz disc to serve as a window sealed into the distal end of the apparatus, then the diseased cervix and adjacent tissues would be exposed to the action of the ultra-violet frequencies. By

[1]Freund: Radiotherapy.

having a separate and longer cap, i.e., hard rubber tube, of a little less diameter and 4 to 6 inches long, with the quartz disc fitted in as now, the lamp shown in cut can be adapted to gynæcological work. The cap could be easily removed and cleaned while the insulating base and metal electrodes could be kept perfectly dry. The quartz disc is more readily fitted into the hard rubber tube cylinder than cemented into a glass tube.

There is no question but that the ultra-violet frequencies thus obtained would serve an excellent purpose, in a good many cervical and uterine conditions, an eroded cervix, for example.

But there are many other means to the same end, and in the use of light energy, the methods pointed out in Chapter XII. and XIII. under the use of the concentrated energy of electric arc spectra, and the concentrated energy of incandescent light spectra, amply suffice.

Strebel[1] also proposed as another form of spark light, the rays given out by the opening spark of a Wagner hammer, with an induction apparatus. He showed that this light, when the interrupting spark is produced by aluminum contacts, is very rich in color rays, though not to so marked an extent as the voltaic arc, but richer even in ultra-violet rays.

The Utilization of the Ultra-Violet Energy from an Influence Machine.—Leduc, who was the first to utilize the ultra-violet rays of the discharge from an influence machine, used as a condenser, a capsule with a quartz end, the latter serving also as a compressor. One may use from five to ten of these condensing lamps connected with the one spark gap of an influence machine. The output of such a machine is so tremendous as compared with the voltage required for a single lamp, that the many can be operated equally well with the one. In this way several patients can be treated at the same time. Leduc also devised an apparatus to use with a powerful induction coil. Both Freund and Strebel

[1]Freund: Radiotherapy.

have pointed to the possible therapeutic utilization of the ultra-violet frequencies in the electric brush light. Strebel constructed a small condenser which projects these discharges in a circular plane.

The following arrangement of apparatus, as a source of intense ultra-violet activity, was suggested by Mr. W. S. Andrews. The author is indebted to Professor Samuel

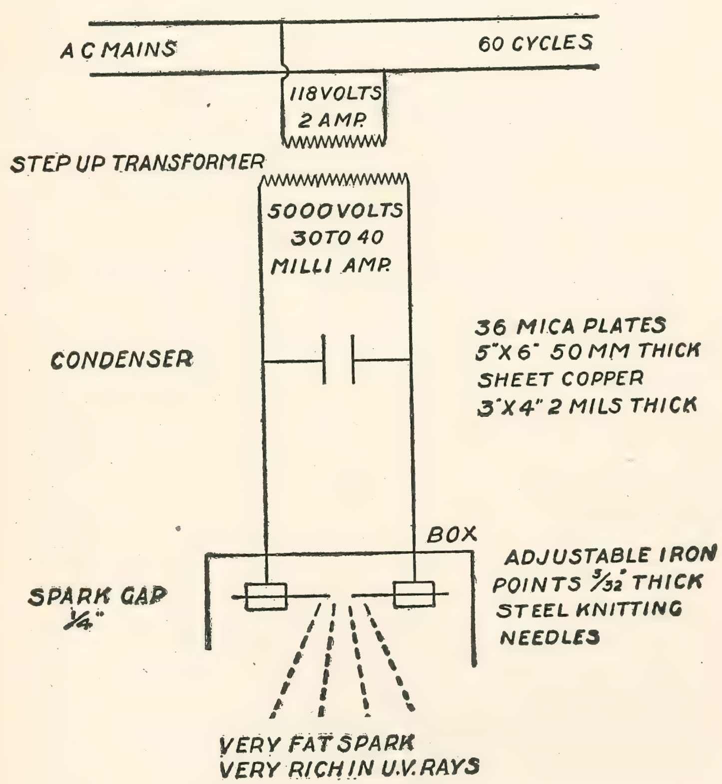

FIG. 37.

Sheldon,[1] of the Brooklyn Polytechnic Institute, for communicating the suggestion, and for the drawing shown in the accompanying cut.

[1]Personal communication.

There are also to be had other makes of apparatus to use with static machines or coils for the production of ultra-violet rays, but the underlying principle is the same in all.

The Strong Ultra-Violet Spark Lamp.—There is a very excellent one to use with the Strong high frequency apparatus. The principle of this coil is that of Tesla's. These coils are well adapted to the production of ultra-violet frequencies.

An Alternating-Current Arc for Spark Light.—There is another which is largely used, shown in Fig. 38. This is connected directly with the alternating-current mains. It is a very efficient lamp, and the one used in the case of pemphigus reported in this connection was of this make.

The current is to be turned on gradually to prevent undue heating of the lamp mechanisms. Care should be taken in using these lamps with powerful coils not to permit too much current to pass. In this way undue heat will be generated, melting the hard rubber of which the base is made.

The Action of Spark Light upon the Skin.—The effect upon the skin from the light energy from these condenser lamps whether excited by an induction coil or by a static machine is exactly the same as that produced by the effective energy of the voltaic arc; that is they produce erythema and pigmentation. The biological action of the light energy from these sources is to a very great extent that of ultra-violet light energy, for, as has been stated, there are very few of the longer and slower frequencies produced in this way.

It is probable also that there are effects due to the electric waves originating in the spark. Still with the Görl lamps there is apparently no evidence of any electrical action. With the cylindrical glass tubes for vaginal or rectal use, there is unquestionably an effect from the electrical discharge as well. Owing to the length of the rods supporting the metal balls between which the spark flashes they are apt not to keep the centre of the tube and the discharge then leaps off to the sides of the glass tube.

Therapeutic Use of Spark Light.—No one seems to have published so extensive reports from the use of these Spark Condenser or ultra-violet lamps as Strebel. According to him, treatment proceeds rapidly with these lamps, as a surface of at least five centimetres in diameter can be exposed to the action of the ultra-violet rays at once. The light is absolutely cold, which renders its use very simple and easy. Exposures may be made every one to three days, and from fifteen minutes to an hour in duration. Strebel claims good results. In lupus vulgaris, distinct improvement followed several exposures of forty-five minutes each; venereal ulcers healed after several exposures of half an hour each; obstinate psoriasis, from eight exposures of one and one-half hours each; a plaque of herpes tonsurans as large as a five mark piece (about the size of a silver dollar) twenty-one exposures of half an hour each; sycosis, twelve exposures of twenty-five to thirty minutes each, simultaneous epilation; eczema madidans two exposures; ulcus cruris, healing after nine to twenty exposures; and alopecia areata eight exposures. Also according to Strebel as reported by Freund, this treatment has been very successful with diseases of the mucous membrane, arresting the discharge and causing the disease to disappear, fluor albus blenorrhagia, with twenty minutes exposure every fourth day combined with salt water douches; chronic metritis from ten intra-uterine exposures to the light energy; gonorrhœa in the male, ten exposures of fifteen minutes duration; venereal warts three exposures.

Strebel admits that the treatment may possibly produce violent irritation of the mucous membrane, inflammatory swelling and pain on micturition.

The author with an equipment consisting of various sources of light energy from a Görl lamp to an 80-ampère arc, has used the former rarely because of the greater value of the others. Still it has been used in connection with a powerful influence machine (Holtz) sufficiently to determine its individual and comparative value. A patient with pelvic cancer, who was under care for X ray treatment reported

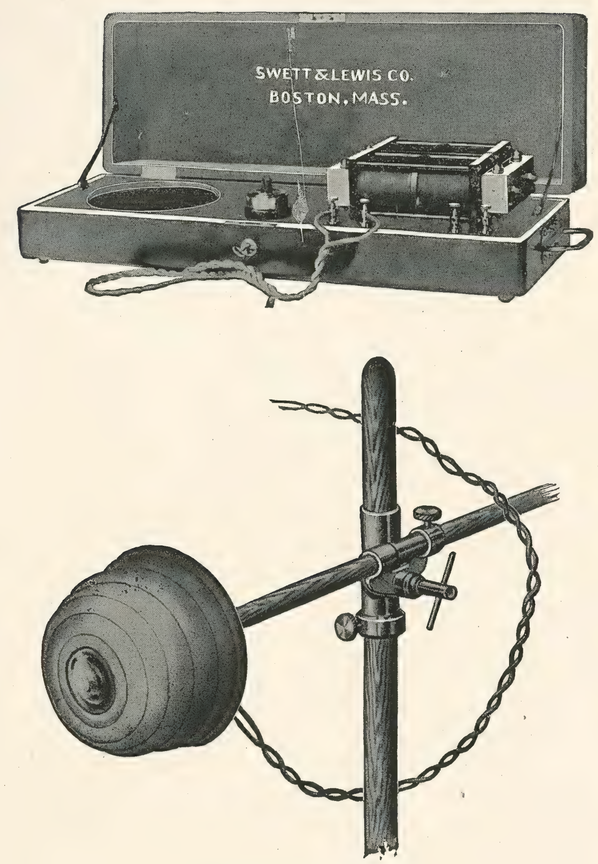

Fig. 38.—The Ultra.

at the office one morning complaining bitterly of great distress about the vulva and to the left side. Upon examination the left labia majora was found badly swollen, red, hot, sensitive and extremely painful. A ten-minute exposure to the ultra-violet light energy from the condenser lamp shown in the cut resulted in immediate relief from pain and sensitiveness, with greatly diminished swelling and lessened heat. As the day wore on all discomfort disappeared and the following morning the labia was practically normal, there being neither heat, swelling, sensitiveness nor pain.

For this same class of cases, the author has used the condenser lamp, placing it directly over the opening of the proximal end of the cylindrical glass speculum and in this way bringing the cervix uteri under the influence of the ultra-violet light energy. The same sense of comfort has followed its use as from light from other sources.

The Field of Ultra-Violet Energy Alone is Limited.—The field of ultra-violet energy alone is comparatively small. When it is a part of the complex of light energy from a source such as the voltaic arc, its field of usefulness is very much greater. In the first instance, the very short and high frequencies which are so little penetrable only are active, but in the latter it is both the ultra-violet and the blue. Freund's experimental work proved that the blue, violet and the ultra-violet, those up to the cadium line, penetrate the epidermis. The ultra-violet, however, pierce the epidermis and are able to reach the lower layers of the skin only. These penetrant ultra-violet frequencies, according to Freund, constitute a third part of the ultra-violet spectrum as it is known. Bernard and Morgan, it will be recalled, found that it was the energy of the middle third of the ultra-violet spectrum which produced bactericidal action, and that the energy which excited tissue reaction was also in the ultra-violet region. This they did not accurately locate, however.

Inflammatory Reaction and Penetration not Proportional.—The fact should not be lost sight of that the superficial inflammatory reaction established bears no relation to

the amount of penetration. There may be secured for example, a profound penetration, sufficient to promote absorption of a deeply situated exudate, but without corresponding tissue reaction; or on the other hand an intense erythema even to severe inflammation of the skin may be produced without penetrating the true skin.

Choice of Source of Light Energy Dependent upon Pathology to be Treated.—Upon these facts, therefore, depends our choice of a source of light energy. It has been clearly shown that in deep-seated well-organized lupus processes, tuberculous processes, lung or joint, an exudate about a joint or the spinal cord, that a source of light energy rich in the more penetrant as well as the higher and more refrangible frequencies is called for. But if the lesion is superficial and of recent standing, then a source of light energy from the ultra-violet spectrum is sufficient.

If the individual physician who has a static machine or an X ray coil, does not care to add the more expensive arc light mechanism to his equipment he will find that the addition of any one of the ultra-violet or spark condenser lamps described will render him good service in many recent and superficial conditions. It will be an addition to a surgical armamentarium, placing in the surgeon's hands a simple portable inexpensive mechanism the use of which will tend to facilitate the healing of both wounds and contusions, of simple joint injuries, lacerated wounds, venereal ulcers, in fact any of the conditions referred to. It must be remembered, however, that it will only be of avail in recent and superficial growths.

Brush Light or Discharges in Skin Conditions.—Brush light or discharge has been used by a great many operators in the treatment of skin conditions, and while much may be accomplished by its use the results are only obtained after a very long time. Freund substantiates this statement from his own experience.

It has long been recognized by those habitually using static electricity, that from its general administration,

patients with various skin affections, eczema for example, have recovered.

But not until the development of light therapeutics in skin conditions by Finsen and his followers was the nature of the active energy understood or appreciated.

Technique the Same as with Carbon and Iron Arcs.—The technique of applications is the same with the spark condenser or ultra-violet lamps as with the carbon and the iron voltaic arcs. As the ultra-violet frequencies do not penetrate the skin it is necessary to dehæmatize the tissues as for the use of the concentrated energy of the arc. To this end compression may be used or adrenalin diffused cataphorically at the will of the operator. It is difficult to draw hard and fast lines between the energy as manifested from different parts of the spectrum but in these condenser lamps it is practically a question of pure ultra-violet frequencies alone.

Pemphigus Neonatorum.—In the summer of 1903 the author was consulted by the father of a boy aged 9, who from infancy had had constantly recurring attacks of a skin disease, followed by complete desquamation. The consultation was for the purpose of knowing whether the use of light energy offered any hope of recovery, for recourse had been had to every known remedy at the hands of skilled physicians and dermatologists without success. The use of a chemically active light energy was advised, but owing to the fact that the patient was very frail it was not thought best to bring him to New York during the summer. Meanwhile Dr. C. R. Dickson,[1] who had referred the patient to the author, added a spark condenser lamp with iron electrodes to his equipment to be used with an alternating current.

Between July 16 and August 11, 1903, the patient was exposed five times to this source of light energy. In the latter part of December, 1903, the father reported that the child remained comparatively well. Here the active energy was that of the ultra-violet frequencies. There are two rea-

[1]Dr. C. R. Dickson, Toronto: Personal communication.

sons why these very little penetrating, but very precious frequencies, with their ability to shake up or agitate little things in their path, bacteria, for example, sufficed. (1) The age of the patient which meant, aside from the advantages usually pertaining to youth, a soft tender skin, and (2) the nature of the disease itself with its ever-recurring desquamation and formation of a new skin, serving as it did to increase the softness and, therefore, penetrability of the skin by the ultra-violet frequencies.

As the disease is a rare one in this country, the following conclusions of Eustis,[1] who has made a recent study of the subject may be of interest and service.

(1) In cases of pemphigus a diplococcus can be isolated from the contents of the bullæ.

(2) This diplococcus when injected intravenously into the rabbit will cause death.

(3) A diplococcus removed from the blood of the rabbit and identical with that obtained from a case of pemphigus vulgaris, when injected into the pig (*Sus Scrofa*) produces a pustular eruption in the latter animal attended with a mild constitutional disturbance.

(4) Arsenic is the main remedy to be relied upon in the treatment of pemphigus vulgaris.

The necessity of acting directly upon the blood in pemphigus is very apparent, and the main remedy in the disease—arsenic—is one noted for its power to increase the oxygen carrying capacity and number of red blood corpuscles. Hence the value of ultra-violet frequencies with their affinity for oxygen and consequent stimulus to the oxygenating power of the blood. Every known remedy had been used in the case reported, arsenic among others but without result.[2]

[1] A Case of Pemphigus Vulgaris with Some Observations on its Bacteriology, A. C. Eustis, B.S., Ph.D., M.D., American Medicine, April 14, 1904.

[2] Subsequent to the preparation of this chapter the following detailed account of this case was furnished the author by Dr. Dickson.

Case. Pemphigus.—1903, June 24. Consulted by father of patient at advice of Dr. Grover W. Wende of Buffalo, N. Y., for opinion as to utility of phototherapy. Owing to extensive character of lesion as described by father, Dr. Dickson suggested that child be placed in care of Dr. Margaret A. Cleaves, of New York, for arc light bath treatment, in order that larger areas of skin might be subjected to treatment at one time than would be possible with the Finsen light or any of its many modifications. Owing to the distance from home and the state of the child's health this was not thought possible by the parents.

July 16. The child was brought to Dr. C. R. Dickson, in Toronto, and the following history was given: J. T., boy, aged 9 years, very irritable since 6 weeks of age, diapers when wet caused much irritation, various remedies, both external and internal, had been resorted to without avail and many physicians had been consulted by the physician in attendance. On June 20, 1901, the boy had been taken to Dr. Grover W. Wende at Buffalo, and an ointment, wash and pills had been prescribed under which there was some improvement. On September 23 the boy was again taken to Buffalo and was seen in consultation with Dr. G. W. Wende and others, who made a blood count and found quality excellent, a microscopical examination of skin was also made.

On December 8 a mild attack of measles supervening, all skin treatment was omitted until the 18th, in spite of which the skin lesion in large measure disappeared, but on the 25th exhibited signs of return. On January 1, 1902, his weight was 38¾ pounds, at later dates it varied, e.g., on February 13 it was 40¼, while on March 10, 1903, it had decreased to 35¾. The general condition varied much also.

On July 16, 1903, the date of his visit to Toronto, the child was peevish, irritable and nervous and presented a revolting appearance. The entire scalp was devoid of hair, eyebrows and eyelashes were absent. Upper and lower eyelids were swollen so that eyes could be only partially opened,

conjunctivæ much injected, a purulent discharge excoriating lower lids at canthi, upper lip swollen and excoriated from discharge from nose, ears swollen, excoriated and discharging, and face otherwise much involved in lesion. Lesion also involves both wrists and dorsal and palmar aspects of hands and fingers with atrophy and falling out of finger nails. Both buttocks, groins and sides of chest and the abdomen exhibit the lesion, as also both thighs, hips, knees, ankles, heels, soles of feet, toes. In fact there were few spots of entire body quite free. Papules, pustules and crusts were abundant everywhere, there was much pigmentation and extensive desquamation of cuticle. Thighs were semi-flexed on abdomen, and legs on thighs. From this and the condition of heels, it was impossible for him to stand alone, much less walk properly. No boots could be worn, and his stockings and other clothing had to be removed with the greatest care in order to avoid hurting him from catching on the numerous crusts and scales.

On the occasion of this visit the patient was exposed to ultra-violet rays from an "Ultra" lamp, a form with iron electrodes, and used with the alternating current. No compressor was used nor blanching mixture, the lamp was placed about 3½ inches from the part to be rayed and moved from place to place with an exposure of 4 minutes to each locality. In order that effects of treatment might be noted more readily, the first exposure was to backs of both hands, left foot heel and ankle, left knee and left side of face. On July 22 the palms of hands, right foot, right knee, right side, and right half of face, were treated similarly. On July 30, August 6 and 11 further treatments were given, five in all. Improvement in condition of skin while slow, was gradual and progressive. Reaction had not been very marked after each séance, but after the last, diarrhœa supervened which proved troublesome, especially in view of the fact that mal-assimilation had always been a prominent feature of the case.

Improvement continued, by middle of September was

walking unaided again, weight also increased from 41¼ pounds on September 24 to 48½ on March 17, 1904.

In February, 1904, early a slight recurrence manifested itself, chiefly in heels, toes, knees and fingers, and on April 4, he came to Toronto for further treatment. A very great improvement since last treatment was now noticeable. With exception of above localities, which were only slightly affected, the skin was in healthy condition throughout, a profusion of downy hair covered the scalp, eyebrows and lashes were also reappearing, the patient also walked quite well unaided, and continued to gain in weight. He was again treated on April 15 and on June 3, and is to receive further treatment.

A Case of Chronic Pemphigus.—Dr. Max Heim[1] reports two cases of chronic pemphigus in which he has employed the blue light from an arc lamp which produced a very rapid cure after every other known remedy had failed.

The first case occurred two years since, while the second was a recent occurrence; the history of the latter case will suffice for both.

In 1877 the patient had a vesicular eruption of the internal portion of the left forearm following a cut which had taken from eight to ten weeks to cicatrize. At first there appeared small confluent vesicles resting on a red base, containing a clear pale yellow liquid, and producing a burning sensation which caused insomnia. Some bullæ healed, but soon recurred. For nine months the patient was treated with different powders and pomades; the bullæ which slowly healed being always followed by the appearance of new lesions. During 6 months the patient was seen twice a week by Dr. Löbker. After 15 months a complete cure seemed to have been obtained. In 1901 the patient had a new eruption of pemphigus on the third and fourth fingers, which spread to the dorsal part of the hand. The usual therapeutic measures, as well as medicated baths, failed to produce

[1]Revue Internationale d'Électrothérapie et de Radiothérapie, Fev. et Mars, 1904, p. 238.

any results. The bullæ became more numerous, attacking the dorsal face of the wrist also, and at the end of 8 months the entire dorsal part of the hand showed very numerous bullæ. These were about the size of a pea, resting on a red base, the interspaces showing desquamation and crusts. Some of the bullæ had purulent contents. The hand was painful, and the general condition bad.

In this case the pemphigus had an intimate connection with hysteria that could not be mistaken. Indeed, it could have been called hysterical pemphigus.

In treating the case an intense light with the arc lamp, blue glass and a reflector were employed. The therapeutic effect of the light was surprising, and manifested itself even after the first application. The bullæ commenced to dry up, and the contents of the smaller ones rapidly diminished. The larger bullæ had been pierced with an aseptic needle before the application of the blue light treatment. After three or four séances a marked amelioration of the conditions was observed. Nine bullæ, which had persisted in recurring, no longer showed themselves. In the space of 12 or 13 days, after 9 séances of light treatment, the cure of the pemphigus was complete.

A proof of the marvellous effect of the local application of blue light was the rapid cure after an exposure of 20 minutes of two small bullæ, which had been inocculated by scratching the right hand with the left. These bullæ, as large as peas, situated between the index and middle fingers, disappeared after one exposure.

This case is analogous to one treated two years ago, and can only be explained by the bactericidal power of light.

It must be admitted, comments Heim, that the local application of the arc light brought about the cure of these cases of chronic pemphigus, reputed to be incurable and almost always fatal, when the affection was still in its early stages.

The author is also indebted to Dr. C. R. Dickson, of Toronto, for the following cases:

Sycosis (Barber's Itch).—Epilation was not resorted to, nor the beard removed. The spots, five or six in number on and below the chin, were swabbed over with adrenalin chlorid solution, 1/10000, and each spot was then subjected to ultra-violet energy for 3 or 4 minutes, the lamp being at a distance of half an inch. Five exposures sufficed, and then days after the first appearance of the lesion no sign of it could be detected. There was no recurrence.

Furuncle on Neck of Child with Suppuration well Established.—After applying solution of adrenalin chlorid as above, ten minutes exposure to ultra-violet energy caused the disappearance of areola of redness and marked lessening of the swelling the following day. After two further treatments of about 5 minutes each on succeeding days no trace of boil could be detected.

Recurrent Carbuncle Aborted in One Case by One Application, in a Second by Two of Ten Minutes.—Both cases occurred in men. In the former the subsequent desquamation of cuticle was quite extensive, as of a severe sunburn.

Itching of Small Lupus Vulgaris Nodule (size of pea) on Face.—The patient was a man and was relieved by one treatment. The lupus disappeared after three 10-minute exposures.

Inhibitory action secured on epithelioma of lip, inoperable, recurrent.

Cases of acne rosaceæ, and also acne vulgaris have been treated with excellent results.

In a case of suppurating cervical gland healing after incision was promoted by exposure to ultra-violet energy. In a case of angioma exposure to ultra-violet energy was made prior to electrolysis of the same resulting in an improved condition of the skin.

Relief of Neuralgia.—Dickson's experience is confirmatory of a mass of clinical evidence as to the beneficial influence of light energy in neuralgic conditions.

AUTHOR'S NOTE.—Dr. Dickson writes that in cases of long standing lupus vulgaris he has had excellent results. As these cases are to be reported at Int. Elec. Congress they cannot be reported here.

The Concentrated Energy of the Spectra of Iron-Electric Arcs or Ultra-Violet Frequencies in Syphilis. Syphilis a Sub-Catabolic Disease.—The theory promulgated by Wakefield that syphilis and leprosy are to be regarded as sub-catabolic diseases, not only appeals to the reason but offers the best rationale for the action of therapeutic measures known to be of use. This theory may be briefly formulated as follows:

Disease symptoms, whether the disease is due to a micro-organism or not, are due to toxins or chemical poisons. These toxins or poisons act by reducing the catabolic functions of the body tissues, and the result of such a state of depressed activity is the disease as we know it. This theory only refers to what the author calls the sub-catabolic diseases.[1] Leprosy is regarded as the best example of the extreme condition of catabolic stasis. In the treatment of all these conditions, agents which produce hyperæmia of the tissues are most valuable. To this end many physical agents should prove of great value. Light, massage, oil, inunctions, electricity, mechanical vibration, but of all these agents, light, by reason of its physical laws and physiological action, should be of the greatest benefit. Here and there scattered throughout medical literature, vague references are to be found as to the value of light in its treatment.

As syphilis is a sub-catabolic disease, or a disease of sub-oxidation, the therapeutic indication is for the use of oxidizing agents. In the use of light energy there should be selected a light rich in the frequencies of vibrational activity or wave length, which is capable of being absorbed by the blood. In both syphilis and leprosy, parasiticides, *per se,* however powerful, are of no value unless they are active oxidants. Active oxidants are of the greatest value even if devoid of parasiticide properties. It is upon the blood stream that it is necessary to act in order to secure results Mercury in the primary stage of syphilis does not even de-

[1]Wakefield: New York Medical Record, January 1, 1904. Syphilis and Leprosy as Sub-Catabolic Diseases.

stroy the virus, as is proven by the appearance of the second and tertiary manifestations.

Theories as to the Active Agent in Light and Fresh Air Treatment of Syphilis.—In a paper read before the Medical Society of Berlin, 1898, M. Below[1] reported 122 patients treated by means of arc and incandescent light baths, with 67 cures, 36 improvements and 9 without results. The best of results were obtained in lupus, ulcers of the legs, muscular rheumatism and syphilis. He attributed the action in syphilis to the profuse perspiration produced, and referred to the habit of the natives of Hayti and on the coast of Mexico, who had acquired syphilis, of covering themselves with sand on the sea beach and exposing themselves to the sunlight, as exercising a similar influence. In the discussion which followed the presentation of the paper, Below's theory as to the mode of action was not regarded as the correct one by his confrères. They attributed such curative action as resulted to the heat of the sun's rays, not to the perspiration.

A physician of large experience in connection with extensive mining interests, stated in conversation with the author that his syphilitic patients always did best when they led an outdoor life. To what is the beneficial effect due? Below attributed it to the profuse perspiration induced, his confrères to thermal activities and the mining physician associated it with out-of-door life. That all these conditions are beneficial goes without saying, but so to speak, what is the active principle at work and how does it act?

Theory as to the Physical Action of Ultra-Violet Energy as Applied to Syphilis.—To understand physiologic action and consequent therapeutic result necessitates an equal understanding of the physical nature of the agent and the laws governing it. It is only necessary to refer to the spectrum composed as it is of a very great range of frequencies capable of producing chemical, luminous and thermal ef-

[1]Below, Revue Internationale d'Électrothérapie, Mar., Apr. and May, 1898. Quoted by the author in "The Electric Arc Bath." Transactions Am. Electro-Therapeutic Ass'n, 1898.

fects, when all visible frequencies are used, and more intense chemical effects when mechanisms are so arranged as to give not only all the visible chemical frequencies, but the invisible or ultra-violet as well, to clearly establish the manner in which light acts to cure a disease like syphilis. If the curative action depended only upon the establishment of free perspiration, or upon the thermal activities, the methods practiced by the natives of the countries mentioned would, by reason of results, have become an established one. Such is not the case. As the disease is one uninfluenced by parasiticides, and represents a condition of catabolic stasis, indicating the need of powerful oxidants, then that part of the spectrum which is capable not only of producing oxidation, but of being absorbed by the blood is indicated. To this end, the chemical frequencies and their mode of action demand our attention.

Ultra-violet rays have a great affinity for oxygen, and the fact that the blood absorbs these rays better than any other tissue, renders their application in a sub-catabolic disease, like syphilis, a rational one.

In the rhythmic flow of the short high frequency vibrations of light, both of the visible and invisible chemical region, but especially of the invisible or ultra-violet, there is a rate of vibration or oscillatory movement which is in harmony or synchronism with the rate of vibration or swing of the molecules of oxygen. By the penetration of these frequencies, and their great affinity for oxygen, the red blood corpuscle, the oxygen carrier of the blood, is immediately acted upon. As a result of their action, a stimulus is imparted to the life and function of the corpuscles of the locality treated, increasing thereby, not only the amount of oxygen carried by the individual corpuscle but by the entire blood stream. Just as each individual wave of light made up of its oscillating corpuscles receives an impetus from the impingement of the succession of corpuscle upon corpuscle, causing not only each other to swing but another and another, so the movement established by the oscillatory action

of the light wave upon the oscillatory movement of the oxygen molecule of the red blood corpuscle is not confined to the immediate locality acted upon, but extends that influence ultimately to the entire circulation. This means increased chemical action or oxidation. In other words, the light energy through its physical action is converted into chemical energy. An increase of red blood corpuscles means increased leucocytosis as well as increased absorptive activity. There is a loss in the energy of oscillation the further removed from the site of application, and just as the energy of the ripple on the water caused by dropping a pebble or stone therein is diminished by distance, so the effect of a single local application must be very slightly felt at a distance. As the dropping of successive pebbles will maintain the energy of the ripple, so will successive applications of the light energies maintain the oscillatory swing of corpuscles and correspondingly increased chemical activity, until the entire circulation is influenced and the lesion controlled. This should be equally true in the treatment of a systemic condition as in that of a local lesion, a tertiary syphilitic ulcer, for example. The normal functions of the living organism are accentuated, and the fight begins, which, with skilled, sufficiently long and frequently repeated applications of light, continued over sufficient length of time, results in the overthrow of the enemy. If the impact is not that of the same rate of oscillation, the stimulus imparted may not only be unproductive of good, but harmful as well. From the irregular, disorderly and infrequent rate of vibration of the Roentgen ray in the case detailed below, there was no effect produced, therefore it stands to reason that the necessary stimulus to the oxygen-carrying power of the red blood corpuscle was not imparted. In an acute syphilitic lesion, a primary chancre, the action of the latter was, in a case reported to the author, of such a nature as to cause an intense inflammatory action, so intense as to cause some alarm on the part of the physician as to the outcome. In the illustrative case which follows, there was no perspiration

induced, no thermal frequencies of light used, specific medication had been administered and the Roentgen ray used for a period of two months without effect. The result secured was due entirely to the action of cold light; in other words, to that part of the spectrum chemically active, blue, indigo, violet, and especially ultra-violet, as a water-cooled iron electrode lamp was used, and iron gives the maximum of ultra-violet frequencies.

Tertiary Syphilis.—December 21, 1904. Mrs. W., age 30, married, no children, never pregnant. Father living, age 73. Mother dead at 53, "menopause." Patient one of eight children, all well. Health always good, well at time of marriage and since until the present trouble. Husband is also in good health, but had an operation for hemorrhoids five years since. In June, 1903, patient wakened with eye swollen, physician called, and was under his care for three months. The tissues about the eye were swollen and red, but she suffered no pain. The diagnosis made by the physician in attendance was that of poisoning from insect bite. In August, 1903, the swelling under the eye was opened, discharging pus freely. In December, 1903, she was operated on for a "fistulous opening underneath the right eye." In May, 1904, she began to have trouble with her nose. Noticed it was very much swollen. It grew gradually worse. In October a large ulcerated sore appeared on the upper lip. On December 20, when first seen, bridge of nose broken down; septum perforated, ulceration of left nasal cavity, characteristic discharge. Lip swollen, indurated, dusky red, ulcerated area of size of nickel. Hole with clean-cut edges into which forefinger could be laid. Discharge, sluggish circulation. At the time of coming under care, the patient had been on mixed treatment for over two months and had also had from 12 to 14 exposures to the X ray at intervals of two days each. Each X ray exposure was followed by the use of the brush discharge from a static machine. Very little improvement, if any, was noticed from the combined use of the X ray, brush discharge and mixed treatment. December 21,

1903, patient came under the author's care, and treatment by means of the chemical frequencies of light was instituted.

The water-cooled iron electrode lamp, shown in Chapter XII., modelled after the one devised by Sophus Bang, was used. Treatment was given twice a week only. Before each treatment the lip was carefully freed from the crusts due to the discharge from the ulcerated area and from the nose, by the use of a peroxid of hydrogen solution. Firm pressure was made upon the part with the compressing lens of the lamp, to secure the necessary anæmia, and the light applied at the first sitting for 5 minutes only; subsequent exposures were 10 minutes each in duration. Slight reaction was established by first exposure, marked from second treatment, followed by diminution of the induration, swelling and discharge. The sore began to take on a healthy appearance and at the end of three weeks was absolutely healed, only slight redness of skin noticed. By the end of the fourth week, this redness had passed, and the skin was smooth, of normal coloring and without any indurated scar tissue whatever. There was a modification of the discharge from the nose with the healing in the lip, but treatment was directed to the nasal cavity after the healing process was established in the lip. At first, the light from the Marine Searchlight, Fig. 23, was projected into the nasal cavity. With the establishment of improvement, a small incandescent light was carried directly into the nares and kept in position for 5 minutes to each naris. Three such exposures were made, with the result of cessation of the nasal discharge, and healing of the mucous membrane around the perforation. At the time of her last visit, January 28, 1904, the nose, as well as lip, was absolutely well. There remained the white and glazed appearance of the nasal mucous membrane about the perforation and the deformity, to testify to the nature of the condition from which she had suffered. The interesting features of this case are (1) the history. If the patient is to be believed, infection came from an insect bite. (2) The infrequent treatments, but two a week; (3)

the improvement in the nasal ulceration as evidenced by the lessened discharge and appearance of the mucous membrane from the application of the light to the lip only; and (4) the intense chemical activity of the light from the water-cooled iron electrode lamp. This was a condition eminently suitable for a light rich in the violet and ultra-violet frequencies, but not necessarily a light of great quantity. By the oscillatory swing of the corpuscles of the chemical waves of light, especially the precious ultra-violet, the oxygen molecules were made to vibrate more energetically at their own rate, and the influence extended not only to the oxygen carriers of the immediate locality, but to those of the nearby circulation, as was evidenced by a beginning improvement in the nasal mucous membrane before a direct application of light was made thereto.

Strebel[1] reports the healing of venereal warts with three exposures and venereal ulcers with several exposures of half an hour each, utilizing the ultra-violet frequencies from a spark discharge, or the condenser lamp. A similar lamp is shown in Fig. 35. As the spark both from a static machine and a high potential and frequency coil is rich in ultra-violet frequencies, this little lamp is very useful, where deep penetration and large quantity of light are not needed.

M. Sorgo[2] reported to the Vienna Society of Internal Medicine, two cases treated by means of concentrated solar light, the one a well-marked case of tubercular laryngitis, the other a case of syphilitic laryngitis. He concentrated the solar rays by means of a laryngoscope upon the ulcerated mucosa of the larynx. Thirty exposures were made, each lasting about an hour. The ulceration cicatrized and the vocal chords resumed their normal color.

The same treatment failed in a case of syphilitic laryngitis. Uniform results do not follow uniform methods in

[1]Die Physiolog. Wirkungen der Polentl. Sitzungsber. d. k. Akad. d. Wissensch. in Wien, Naturw. Klasse, Vol. CIX., Part III., 1900, p. 652.

[2]Revue Internationale d'Électrothérapie, Jan., 1904. Abst. from article by M. Romme, Presse Medicale.

every case. This may be a matter of the individual, and one can but question whether the failure to secure healing in the syphilitic case was not due to the absence of the ultra-violet frequencies. Sunlight, although rich at its source, is deficient in the ultra-violet frequencies at the earth's surface, while the electric arc, especially with iron electrodes, and also the spark light is very rich in them. Single failures nor single successes do not make a rule, but the author believes a source of light rich in ultra-violet frequencies, a more powerful oxidant, might have secured a better result.

The chemical frequencies of light have been shown to be of value in œzena also. The relation which the condition bears to syphilis indicates the same mode of action.

By the use of the arc light projected into the nasal fossæ through the nares dilated for the purpose, or sometimes concentrated upon tubes of crystal introduced within the fossæ, M. Dionisio[1] has observed that where the treatment was administered regularly, there was a remarkable diminution of the secretion, crusts and fœtid odor. Dionisio states that he does not at this time dare affirm the permanency of the results obtained.

Ultra-Violet Light Energy in Syphilitic Chancre, Gummata, Etc.—Freund[2] reports that G. Barbensi and Strebel[3] treated primary syphilitic chancre, gummata and soft chancre with concentrated arc light energy and also with iron electrode and spark condenser lamps, utilizing in the two latter mechanisms the intense chemical activity of the ultra-violet frequencies, as has been considered by the author under syphilis.

While they found that the local lesion in the case of primary chancre heals quickly under the influence of the ultra-violet light energy, the secondary eruptions were not thereby prevented, nor in the opinion of the author should

[1]Dr. Ignozio Dionisio, Gasette Medica Italiana, No. 6, 1902.

[2]Freund: Radiotherapy, p. 512.

[3]Revisita Critica di Clinica Medica. Quoted by Foveau de Courmelles in L'année Électrique, 1902, p. 392.

they. The entire blood stream must be acted upon and while it is indirectly and to a degree influenced by such a topical application, the expenditure of light energy is not sufficiently extensive or energetic to influence it in its entirety. To this end every square inch of the superficies of the body should be brought under the influence of the powerful energy of concentrated arcs, iron and carbon, from which a beam of 10 to 12 inches in diameter should be projected upon the superficies of the body, or exposed to the action of the non-concentrated energy of powerful arcs in a circuit. In this way the frequencies chemically active would have the power to increase the oxygenating power of the blood supply. Specific medication in syphilis depends upon its power to increase oxidative processes, and while the author would both use and recommend the use of mercury and the iodids according to the stage of the disease in addition to both topical and general treatment by light, she can but question whether the action of light alone, skilfully applied, would not suffice in a good many cases. It is recommended that those who have the equipment and experience, as opportunity offers, make observations in this regard, watching closely, however, in order that the patient's future welfare may not be jeopardized from withholding specific medication. There are limits within which this may be safely done. Strebel found that with venereal ulcers two or three exposures sufficed to heal the sores in a few days. He did not observe any evidence of distinct influence on glandular swellings.

CHAPTER XVII.

Vacuum Tube Discharges, Phenomena and Theory of. Mechanisms, Methods of Use and Therapeutic Indications.

Vacuum Tube Discharges.

While experimenting on the discharge in vacuum it was found by Messrs. de la Rue and Hugo Miller a quarter of a century ago, 1879, that "the stratified discharge in a vacuum tube is simply a magnified form of arc."

To test their theory they made a series of experiments in discharges of various gases at various pressures, with the poles at various distances from one another, and of different shapes. The poles were fixed in a bell jar that could be filled with the different gases and exhausted. A suitable arrangement was made for altering the distance between the poles, and the gases used were air, hydrogen and carbonic acid gas.

In air the pressure varied from 2.6 mm. to 761 mm., the distance varied between 0.54 in. and 6.4 in., the current ranged from 0.01390 weber to 0.04474 weber, and the number of chlorid of silver cells used varied from 10,940 to 11,000. The substance of the electrodes so far as mentioned was brass.

From their experiments they observed that in air the light usually divides itself into at least two and sometimes many parts, with dark spaces between them.

In hydrogen, in some cases, the discharge showed a very definite stratification. In carbonic acid, when the pressure was very small, there was very little evidence of stratifica-

tion; but in both cases the discharge was divided, as in air, into light and dark parts.

It was found that whenever contact was first made the pressure in the bell jar increased more than could be accounted for by the rise of temperature of the enclosed gas. The moment contact was broken the pressure fell almost to what it had been before the contact was made, the slight increase being due to rise of temperature. Experiment showed that this increase took place equally at both terminals. They concluded that it was to be accounted for by the projection of the gas molecules by electrification against the walls of the glass vessel, producing thereby effects of pressure, which, however, are distinct from the molecular motion induced by heat.

Because of the fact that the electric arc is so commonly used as a source of light energy for therapeutic work, the summary of De la Rue and Miller, as it concerns the electric arc is given prefatory to considering the physics of vacuum tubes and their therapeutic uses: "When the discharge takes place there is a sudden dilation of the medium in addition to and distinct from that caused by heat. This dilation ceases instantaneously when the discharge ceases."

"The electric arc and the stratified discharge in vacuum tubes are modifications of the same phenomenon."[1]

This little historic sketch showing the first conception of the unity of the phenomenon of a vacuum tube discharge with the electric arc, which in turn owes its conception to the spark discharge between the terminal balls of the discharging rods of a static machine (see page 83), cannot fail to aid in a comprehension of the unity of all these various phenomena. In the present instance, however, the electrical discharge takes place in tubes of varying degrees of vacuity. In the first place no electrical discharge has ever been passed through a perfect vacuum. Of the many forms of vacuum tubes in use both for experimental and medical work none

[1]The Electric Arc: Aryton.

can be regarded as possessing a perfect vacuum. The degree of vacuum varies according to the purpose for which the tube is constructed. The most efficient X ray tube for example must be of very high vacuum. Discharges through vacua are obtained from the tubes variously known as Crookes tubes, X ray tubes, Tesla tubes, mercury vapor tubes and Geissler tubes. Those which concern this subject especially are tubes of comparatively low vacuum, commonly known as vacuum tubes for medical use. Geissler tubes of commerce are also used for the same purpose and therefore find a place herein.

Dry Air and Other Gases at Ordinary Pressure Non-Conductors of Electricity.—These act like glass, mica and other insulators. Under very strong electric pressure they break down, i.e., overcome their potential difference, and give rise to disruptive discharges, for example, as a thick plate of glass may be pierced by the discharge of a powerful condenser. This may happen with the Leyden jars in circuit, by placing the piece of glass between the terminal balls of the discharging rods of a static machine or of a powerful coil. In fact it has happened in the author's experience in the patient's circuit, i.e., with the machine grounded, which after all is but a Leyden jar discharge, the disruptive discharge passing through the patient's eyeglasses, which unknown to the author were contained in her pocket, in the path of the localization of the spark discharge.

Insulation of Gas Depends upon its Pressure and Density.—The insulating power of a gas increases with its pressure and density. Liquid and oxygen are almost perfect insulators. The insulating power of a gas is decreased by the presence of moisture in the form of vapor or mist. This is supposed to be due to an ionizing of the gas. Ionization is facilitated by diminishing the pressure and density of the gas, until a certain density is reached beyond which conductivity again decreases. This diminution of conductivity is probably from the lack of a sufficient number of ions to carry the current.

Phenomena in a Vacuum Tube.—When an adjustable spark gap of an induction coil or a static machine is connected in parallel with another spark gap in a glass vessel from which the air can be gradually exhausted the appearance of the discharge varies as the density decreases. Should the poles of the exterior spark gap be nearer than the electrodes within the tube, there will be observed at first a series of white, sharp, blinding, zig-zag disruptive charges. But as the density within the tube decreases, the discharge will be shifted from the external to the internal circuit, i.e., the electrodes within the tube. Instead of the former disruptive discharge, the electrical discharge assumes a continuous brush-like glow of great beauty, the color of which will vary with different gases and also with different degrees of vacuity. At this juncture it may be well to point out that in addition to the color of the continuous brush discharge within the tube there will be observed at the superficies of the tube other colors varying from a greenish yellow to a green and sometimes a blue dependent upon the kind of glass used in the construction of these tubes. This brush-like glow becomes more and more a distinct stream of light, passing directly from the anode to the cathode, turning all the numerous curves and corners in the tube as well as around obstacles interposed in its path. As the contained gas diminishes in density, its conductivity gradually increases. This is readily shown by the need of a shorter external spark gap. When the tension of the residual gas is about 1-10 inch of mercury, showing a density of about 1-300 of the normal the best results are obtained. When these conditions are maintained the poles of the external circuit may be brought within a fraction of an inch of each other without a spark passing, indicating that the way of least resistance is in the tube itself. As the rarefaction of the air proceeds below this point the resistance increases, as is shown by the necessity for lengthening the spark gap to prevent the sparking taking place in the external circuit.

Appearance at the Cathode and the Anode.—When this

rarefaction is about 1-300, the cathode is surrounded with a faint bluish light, while from the anode there proceeds a stream of peach-blow colored light. This latter is separated from the glow light of the cathode by a dark space, the thickness of which increases as the rarefaction increases. The stream of light which proceeds from the anode at first appears continuous, but upon reflection upon a rapidly rotating mirror it is seen to be separated or made up of little discs of light separated by dark spaces, which present a wavering appearance, now closing up and then separating. By increasing the vacuum these striæ are distinctly seen without a mirror. By placing volatile liquids within the tube, alcohol, for example, these effects of stratification are increased.

Anodic Stream a Conductor.—The stream of light from the anode behaves like a flexible, movable conductor when carrying a current; it is attracted and repelled by a magnet. It tends to curve around the magnet, just as a flexible wire will wind itself around a magnet, if free to move. If the vacuum tube be made with a hollow core into which a bar magnet can be placed, the light stream will revolve around the magnet. By a reversal of the poles of the magnet or a reversal of the direction of the current through the tube, the stream of light will revolve in the opposite direction. The direction of the rotation shows that the light is made up of positively charged ions, moving forward to the cathode. The discs of light are caused by the collision of the ions, and the dark spaces by their mean free paths, that is, the distance they travel before colliding. The thickness of the dark space around the cathode increases as the rarefaction increases and the striated light stream gradually recedes toward the anode.

The Cathode Rays.—It is when this rarefaction has reached about one-millionth of an atmosphere that the colored striated light stream has entirely disappeared. Apparently it has been driven back by the stream of dark rays from the cathode. An entirely different set of phenomena now appears. But little light is given forth by the tube under these circumstances and no color, save that referred to on

a previous page, caused by the fluorescing of the glass. The color varies with the different kinds of glass but is generally of a yellowish green. The position of the anode becomes a matter of indifference. There must be one somewhere in the tube, but it may be carried from one point to another without producing any effect upon the character of the discharge. The rays proceeding from the cathode pass in straight lines until they strike the end of the tube or some object interposed in their path. The point where they strike is called the anti-cathode. These dark rays emanating from the negative electrode are those known as Cathode Rays.

The peculiarities of these rays have been set forth in Chapter I., under the manifestations of light energy.

It was to explain these facts that Thomson directed his investigations a few years since, 1897, the results of which in relation to the cathode rays are epitomized under that head. Not only do they explain the phenomena of the cathode rays but of the solar and stellar atmosphere, of that of an electric arc, of the action of a spark discharge upon the air as well as within a vacuum.

The phenomena above described apply to a Crookes tube up to the point of the production of the X ray.

Geissler Tubes.—The brilliancy and beauty of the stratification of the electric light are most remarkable when the discharge of the Ruhmkorff coil or the static machine takes place in glass tubes containing a highly rarefied vapor or gas. These phenomena, which were originally investigated by Gassiot, are produced by means of sealed glass tubes first constructed by Geissler, of Bonn, and generally known as Geissler tubes.[1]

These tubes are filled with different gases or vapors, and are then exhausted so that the pressure does not exceed half a millimetre. Two platinum wires are fused into the glass at the respective ends of the tubes. When the two ends of a Geissler tube are connected with a suitable source of E. M. F., a coil or static machine, there are produced

[1]Ganot's Physics.

throughout the tube magnificent lustrous striæ, separated by dark bands. These striæ depend for their shape, color and lustre upon (1) the degree of the vacuum, (2) the nature of the gas or vapor, and (3) the dimensions of the tube. This brilliancy of effect is added to by the fluorescence of the glass produced by the electric discharge, which varies in color, according to the quality of the glass.

Color and Shape of the Striæ with Carbonic Acid.—When carbonic acid is used, under a pressure of a millimetre, the color is greenish, and the striæ have not the same form as in hydrogen. When the tube contains nitrogen gas, the color is yellow. The light in a Geissler tube depends upon the nature of the gas or vapor, not upon the substance of the electrodes.

Spectra of Geissler Tubes Depend upon the Nature of the Gas Contained Therein.—The lights furnished by the Geissler tubes give varying spectra according to the gas with which they are filled, nitrogen, hydrogen, oxygen, and the hydro-carbons when they are decomposed by a prism. When connected with a source of high potential electricity, high tension coil or static machine, and held before the slit of the spectroscope for an analysis of their radiant energy, it is found that no two gases vibrate in the same rates, and, therefore, no two give the same colors.

Identity of Vacuum Tube Discharges with the Aurora Borealis.—This spectroscopic analysis of the radiance of Geissler tubes is one of great interest in the relation it has to the aurora borealis. There is shown in these high vacuum tubes all the rates and colors ever seen in auroral streamers. Columns and curtains are shown in rapidly oscillating electrical discharges. There is no new mode seen in the auroral light. In this connection it may be of interest to note that nine lines in all have been seen in the auroral spectra, but only seven at once. The brightest is the yellow green, although in one aurora Perry saw the red brightest in a curved streamer. A magnetic storm was raging at the time. Another observer noted the green-blue flickering in all parts

of the spectrum at the same display, February 4, 1872. The great aurora of April, 1871, was so brilliant that measures of its spectral lines could be made with a micrometre, and nine were measured.[1]

The green line of wave length, 5,571, is present in every aurora while the others vary with different apparitions. This is termed the aurora line.

According to Vogel, the red line in the auroral spectrum is due to nitrogen, and also the two others toward the violet. The third line in the spectrum of oxygen appears as the fifth in the spectrum of an aurora. Most of the lines are due to the air and its gases. There are iron lines, however, in the auroral light. The wonder of the existence of iron vapor in air is to be explained by the fact that vapor is made of exceedingly fine particles, so fine that they are able to exist in the higher regions of the air against gravity for some time, or in a continual precipitation of iron dust, at least, during the period of an auroral display. Fine particles of iron were caught from space by Nordenskjold,[2] who set up vertical tin tubes in the arctic regions. The aurora is an electric-magnetic disturbance and iron the most magnetic metal.

When the electric pressure, the E. M. F., of a coil or static machine is passing through Crookes or Geissler tubes, by placing them in a magnetic field, i.e., between the two poles of a powerful magnet, there is a great intensification of all the effects. The colors of the lights in the tubes can be changed to imitate the colors of the aurora by simply increasing or decreasing the strength of the invisible magnetic field in which they are placed.

Relation of Current to Change in Color of Stratification. —A change in the current often produces an entire change in the color of the stratifications as, for example, in hydrogen. Here, the change is from blue to pink, due to rise or fall of current.

[1]Larkin: Radiant Energy.
[2]Ibid.

Regularity and Distinctness of Striæ Governed by Regularity of Electrical Discharge.—When the discharge is irregular, and the strata indistinct, the latter will become both steady and distinct upon an alteration in the strength of the current. But even when they are apparently steady and permanent, a telephone will reveal a pulsation in the current.

Color of the Discharge Depends upon the Degree of Rarefaction Even in the Same Gas.—The least resistance to the discharge in hydrogen is at a pressure of 0.642 mm. or 845 M. (symbol for the millionth of an atmosphere). This is when its brilliancy is at its greatest. At a given pressure, air offers a greater resistance than hydrogen; a spark which passes in hydrogen across a distance of 5.6 mm. will go across a distance of only 3 mm. in air. At a pressure of 62 mm., corresponding to an atmospheric height of 12.4 miles, the electric discharge has the carmine tint observed in the auroral display; at a pressure of 1.5 mm., corresponding to a height of 30.96 miles, it is salmon-colored, while at a pressure of 0.8 mm., equal to a height of 33.96 miles, it is of a pale white. The discharge has the greatest brilliancy under a pressure of 0.379 mm. This represents a height of 37.67 miles. These facts as to the degree of pressure giving rise to the various colors of these tubes will enable one to judge of the degree of vacuum of the vacuum tubes in daily use.

Luminescence of Vacuum Tubes.—This is a property of vacuum tubes which depends upon (1) a certain degree of rarefaction of the internal atmosphere of the tube, whether the tube contains conducting filaments or not, (2) the maintenance of incandescent lamps by current of high frequency. In the first instance the luminous effects were obtained by Nikola Tesla in the course of his experiments with currents of high frequency and high potential.

At one time the luminescence of vacuum tubes bade fair to be of practical use for purposes of illumination. This was after Tesla's original experiments and the experimental work done by McFarlane Moore. Moore carried his demon-

strations so far as to beautifully illuminate a small chapel which formed a part of the exhibit of the New York Electrical Exposition at Madison Square Garden a few years since. The light was soft, white but not glaringly so, and diffused by means of vacuum tubes arranged around the cornice of the room. With these tubes the current was let directly in by conducting contacts, and not lighted by a process of induction as with the original Tesla tubes. This method gave great promise of commercial possibilities, which, however, have not yet been attained.

Luminescence in Mercury Vapor Tubes.—There may be added to this category the tubes of mercury vapor known in commerce as the Cooper-Hewitt Mercury Vapor Lamps. In this instance the conduction of electricity takes place by reason of mercury vapor. The reactions taking place in the mercury vapor vacuum tube or lamp may be divided into three groups: (1) those taking place at the positive electrode, (2) those taking place at the negative electrode, and (3) the behavior of the vapor itself.

The conduction of electricity through a vapor is undoubtedly brought about by streams of positively and negatively charged particles, each leaving its respective electrode and travelling toward the other. These streams of charged particles under proper conditions form a luminous column. This varies in character (1) with the current passing, (2) the vapor pressure, and (3) the size of the enclosing vessel.

Eliminating the electrode effects Mr. Hewitt found that the behavior of the mercury vapor under the conditions of this lamp or tube, may be stated as follows: the resistance per unit length of the vapor column, (1) decreases with an increase in the diameter of the tube, (2) with an increase in the current flowing, and (3) with a decrease in the vapor pressure. The watts absorbed per centimetre of length vary of course with the current and resistance. Other things being equal, they increase with an increase in current, with an increase in the diameter of the tube, and with an increase in the vapor pressure.

Luminous Efficiency.—The luminous efficiency of the lamp varies with other conditions; but there is a certain ratio between vapor density and current at which the ratio of light given out to the energy absorbed is a maximum. The resistance of the vapor increases if the tube be placed in a magnetic field. It is believed that the results obtained with mercury vapor will prove true of saturated vapors in general.[1] The spectroscopic analysis of this light has been given in a previous chapter. Rich as it is as a source of ultra-violet energy, this ultra-violet energy is, in common with that of other vacuum tube discharges, of no value in therapeutics above 30 micro-centimetres because of the glass enclosing tube.

Mercury Vapor in Vacuum Tubes of Fused Quartz.—In these experimental tubes not only the light produced in the tube, but the light emitted, by reason of the quartz enclosing tubes, is very rich in ultra-violet energy.

Fluorescence a Phenomenon of Vacuum Tube Discharges.—Fluorescence is so commonly associated with light that the fact of its production by the discharge of a vacuum tube has been construed at once as an evidence that these tubes are sources of great ultra-violet energy. In fact, this explanation of this phenomenon has been carried to such an extent that vacuum tubes of glass to be excited by a coil or static machine are constantly made and sold to the profession as a source of ultra-violet energy. These ethereal vibrations or oscillating swing of light corpuscles are not the only agencies capable of initiating it. The same phenomenon appears even more markedly when a fluorescible substance is introduced into the interior of a Crookes tube. It was proven by Tommasina[2] in his experiments made in 1900 that currents of high potential, in passing between electrodes of aluminum or magnesium through a glass tube filled with water or alcohol, give rise to similar luminous effects. By the fluorescence thus produced not only the in-

[1]E. World and Eng., Dec. 19, 1903.
[2]Medical Electrology and Radiology, May, 1904.

terior of the glass tube and its contents are illuminated but objects in its immediate vicinity are made visible. The degree of illumination thus produced depends (1) on the intensity of the current, (2) on its constancy, and (3) on the source from which it is derived. When a static machine is used, a continuous steady effect is obtained, with a spark coil in the other hand a bright but pulsatory illumination is produced. In the latter instance the number of flashes is proportionate to the frequency of the interruption of the current in the primary circuit. The anode is rendered luminous by the extra current at "closure," the cathode at "break," thereby proving that the fluorescence is anodic. Light produced in this manner is incapable of exciting a platinocyanid screen, but is photo-chemically active.

When the surface of the electrodes is unpolished and somewhat oxidized the effects are best seen; the film, which acts as a dielectric, appears to be excited to fluorescence by the passage of the current.

The luminous effects can be still further increased by the use of phosphorescent media, alcoholic solutions of quinin and gelsemin, of the glycero-alcoholatives of quinin, gelsemin, turmeric, the aqueous solutions of the same substances, or of esculin, fluorescin and eosin.

This effect of vacuum tube discharges is one of high frequency and high potential current, rather than that of the light generated in the tube, as light itself. The phenomenon is seen to a greater advantage when a stream of negatively charged particles, the cathode rays, impinge upon a fluorescible substance introduced into the interior of a Crookes tube. Therefore the ability to excite fluorescence in fluorescible substances with vacuum tube discharges is to be regarded not only as evidence of ultra-violet light but of high frequency discharges in vacuo as well.

The Conductivity of Electricity through Gases.—This has been shown by the brilliant work of Thomson to be due to the action of positively and negatively electrified particles, corresponding to the ion in the electrolytic conduction, which

carries an electric charge, and was named by Dr. Johnson Stoney an "electron."

The electric fluid corresponds to an assemblage of corpuscles, negative electrification, consisting of a collection of these corpuscles; the transference of electrification from place to place being a movement of corpuscles from a place where there is a gain of positive electrification to a place where there is a gain of negative. A positively electrified body, for example, is one which has been deprived of some corpuscles. These corpuscles may either remain free or become attached to molecules of matter with which they come in contact; positive electrification is always associated with ordinary matter, while negative electrification may or may not be, according as the corpuscles are or are not attached to molecules of ordinary matter. Thus in gas at very low pressures the corpuscles are free, but in gases at higher pressures they get attached to the molecules of the gas so that there is not much difference between the effective masses of the positive and negative ions. Although the negative ion moves faster than the positive in gases, the difference is not great.[1]

Theory of Spark Discharge.—Ionization, which is necessary to put the gas into the conducting state required for the passage of the spark, is effected by means of ions, which under the influence of the electric field producing the spark, acquire so great a velocity that when they come into collision with the molecules of the gas through which they are moving they ionize the molecules. In the cases of cathode and Lenard rays ionization of the gas takes place by the rapidly moving ions. Ions in a sufficiently strong electric field can acquire sufficient energy to enable them to act as ionizing agents. This explains some of the phenomena connected with the discharge of electricity produced by the action of ultra-violet light. As the positive ions strike against the cathode, the cathode under this bombardment

[1]Thomson: Conductivity of Electricity Through Gases.

emits negative corpuscles—in fact cathode rays. The continuous supply of negative corpuscles comes from the metal of the cathode, stimulated by the positive ions striking against it. The action of the latter ionizing agents is due to their impacts on the cathode. The rapidly moving negative ions, the corpuscles, are more efficient ionizers than the positive ions, which have a greater mass.

The accompanying cut, due to Sir Oliver Lodge, very

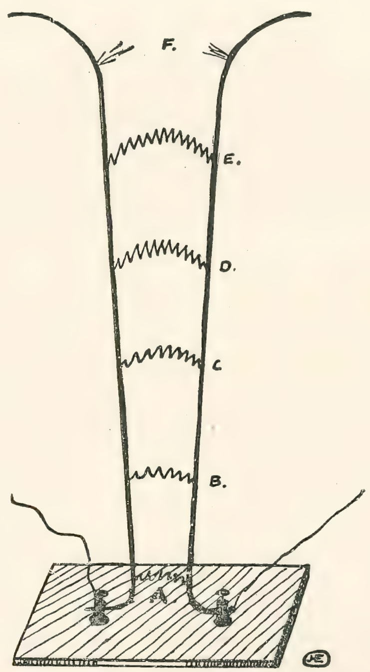

Fig. 39.—Apparatus for illustrating the upward movement of a spark through the ionized and heated air.[1]

prettily illustrates the upward movement of a spark through the ionized and heated air. It begins near the bottom, but by the act of sparking at that level an effluvium or ionized

[1]Sir Oliver Lodge: Archives of the Roentgen Ray, May, 1904.

substance in the air is given off which rises and makes the path easier just above where the spark first appeared. Thus the spark rises, and again the effluvium makes an easier path above it. It runs on up in this fashion until it reaches the top where the wires diverge. They are then too far apart, i.e., the potential difference is too great, for the spark to pass. It breaks off and begins at the bottom again. Each successive spark is just above where the previous one has been. In the ionization of the air an easier path is formed, for the spark rises with it.

Theory of the Discharge through Vacuum Tubes. —The theory of the spark discharge is applied by Thomson to explain some of the phenomena when the discharge passes through a vacuum tube containing gas at a low pressure. The spark discharge originates the ionization of the gas by moving the small negative ions. If, however, the ionization in an electric field not exposed to external ionizing agents, such as Roentgen rays, were solely due to the collisions of corpuscles with the molecules of the gas, a continuous current through the gas would be impossible. To account for the phenomena of the discharge in vacuum tubes it is necessary to have ionization produced by the electric field itself close to the cathode. We shall suppose, says Thomson, that this ionization is produced by the positive ions, and although these require a much greater amount of energy before they can act as ionizers than do the corpuscles, yet the very intense electric field which exists close to the cathode is sufficient to give them, when under its influence they have come up to the cathode, all the energy they require. This might happen in two ways: (1) That the positive ions by collision ionize the molecules of the gas near the cathode; (2) that the positive ions by striking against the surface of the cathode communicate so much energy to the corpuscles contained in the layer of the metal close to the surface of the cathode that they are able to escape from the metal just as they are able to escape from a metal when raised to incandescence.

Whichever of these views is taken, continues Thomson, the consequences will be very much the same; for the strength of the electric field increases so quickly near the surface of the cathode that the kinetic energy possessed by the positive ions, as they arrive quite close to the surface, will be enormously greater than when they are just a little further off, so that any ionization produced by the collision of these positive ions with the molecules of the gas will be practically confined to the layer of gas close to the surface of the cathode. It is possible that the luminous glow which spreads over the cathode is the seat of ionization. Therefore whether (1) the positive ions collide with the molecules of the gas near the electrode or (2) the negative ions start from close to the surface of the cathode, these latter are driven from it by the electric field and soon acquire such velocities that they ionize the gas through which they pass, producing a supply of positive ions which are attracted by the electric field up to the cathode, there to produce a fresh supply of negative corpuscles. The positive and negative ions in the space close to the cathode are therefore mutually dependent; if the supply of either is stopped, that of the other at once fails. This is shown experimentally by an obstacle placed in the dark space of a Crookes tube which throws a shadow, as it were, backwards and forwards. The obstacle stops the supply of positive ions to that portion of the cathode in shadow; it is no longer able to send out negative ions coming from the cathode, the origin of the dark space. On this theory the negative glow is due to the ionization brought about by collisions between molecules of the gas and corpuscles which have started some distance from the cathode. Such corpuscles are the descendants, so to speak, of the corpuscles which started from close to the cathode and which move with very much greater velocity than the glow-producing corpuscles, starting in a much weaker electric field. The corpuscles which start from close to the cathode may, as they are but little absorbed, pass directly through the negative glow. These corpuscles are the cathode rays.

In these discharges through vacuum tubes, when the electric field sinks below a certain value, it can no longer communicate to the corpuscles sufficient energy to make them act as ionizers, so that after the field has sunk to this value ionization ceases, or more accurately it ceases soon after this value is reached, for the corpuscles may retain for some little distance the energy thus acquired in stronger parts of the field and so continue to act as ionizers for a short distance in the weak field. The limit of the negative glow farthest from the cathode marks, according to Thomson, whose theory is quoted, the place where ionization ceases.

Case when the Discharge is not Striated and the Positive Column is of Uniform Intensity.—The corpuscles are continually recombining, so that their number is constantly diminishing, unless there is fresh ionization. If the rates of ionization and recombination are equal, the number of corpuscles will remain constant. Under these given conditions the luminosity will be constant all along the line of discharge and a uniform positive column will exist. If the proportion of the current carried by the negative ions varies at different points in its course the current will be much more deflected by the magnetic field in some places than in others. This is because the negative particles are much more easily influenced by a magnetic field than the positive.

Emission of Rays by Vacuum Tubes.—With the ordinary medical vacuum tubes and Geissler tubes of commerce so far as light energy is concerned, it is only the frequencies of the blue-violet region to which the glass of the tube is transparent. Therefore it is the blue frequencies of the spectrum which are emitted.

If these tubes have a window of quartz sealed in, they may prove a source of ultra-violet energy. It will be recalled that the ultra-violet spectra tends to rise as the temperature increases and these discharges in the low vacuum of the medical tubes ordinarily used are not sources of high

temperature. But if the ultra-violet light is present it will be transmitted through the quartz window. The only such tube which the author has investigated was badly constructed, i.e., the fusing or cementing of the quartz window into the glass, a difficult task, was badly done and the vacuum was correspondingly low. The observed phenomena of the tube were not even comparable with the simple tubes of glass in daily use.

Cathode Rays not Emitted.—Of the two types of vacuum tubes, (1) with leading-in wires and (2) without leading-in wires, the former generate cathode rays, but not the latter. This is because of the necessity for the presence of a target or wire to receive the impact of the positively electrified particles. But as cathode rays are not transmitted through glass it does not matter whether they are generated or not. They can only be conveyed external to the tube through an aluminum window, as was shown by Lenard, when they become Lenard's rays. They concern the physician, therefore, in the relation they sustain to Roentgen rays. It will be recalled that it has been stated that they may be regarded as the parent of the X ray. The latter do not concern us in this connection.

The only frequencies of light or rays emitted by the vacuum tubes for medical work, other than X ray tubes, are those of the blue-violet region.

Mechanisms.—Vacuum tubes for medical use only are constructed of many different shapes and with slightly different degrees of vacuity. Geissler tubes of commerce can be used, but they have no advantage over and above the tubes especially constructed for this purpose. There are two types of vacuum tubes for use therapeutically (1) those having a leading-in wire and (2) those without. In the first instance the wire offers a conducting surface to the terminal end of the interior of the tube for the electrical current. The electrical discharge from vacuum tube electrodes is due to a condenser action, however.

Tubes Containing Conducting Wire.—Tubes with a conducting wire offer an opportunity for a more energetic and uniform conveyance of the electrical discharge than those without. They are useful when it is desired to obtain the effect of the rapidly oscillating electrical discharge as well as that of the light energy.

Tubes Without Leading-in Wires.—With these the electrical discharge is not so much in evidence as the light. The former may produce a considerable sensory disturbance, true electrotonus, when the latter cause very little sensation and the electrotonic effect is less marked.

In some instances, i.e., with some tubes there is no electrotonic effect. This is notably true, the author has observed, when the current from the static machine is passed through a transformer.

With a small Tesla coil placed in circuit with a 12-plate static machine, there was not obtained from either type of vacuum tubes, i.e., with or without leading-in wires, sensory disturbance, electrotonus or fluorescence. The tubes glowed beautifully, but no more brilliantly than when connected directly to the machine. The absence of sensory effect, electrotonus and fluorescence would indicate an absence of the electrical discharge, and under such circumstances the physiological effect should be attributed to the blue-violet frequencies of light alone. When it is desired to use a vacuum tube discharge, without the electrical action, the transformer is placed in circuit, otherwise not. This absence of electrical effect is not true with the transformers manufactured for this purpose, nor has the author found it true with a high tension coil, but with the Tesla coil, which the author has used since 1896, for the purpose of transforming the static current, it is true, having been observed again and again. It is evidently due to the construction of the coil itself, and must bear a relation to the pressure of the static current and the windings and resistance of the coil.

From the medical side at least, there is much in relation to vacuum tube discharges demanding study and investigation.

From both varieties of tubes, however, are to be obtained the action of a chemically active light energy—not ultra-violet but blue-violet—therefore, the effect is twofold, i.e., that of a high frequency discharge, itself next of kin to light, and that of light.

Vacuum Tube Discharges in Therapeutics.—These vacuum tube discharges serve a very useful purpose in therapeutics. The mechanisms may be connected (1) to a high tension coil, (2) to a static machine. In both instances a transformer may be used, but not necessarily. Leyden jars may be interpolated in the circuit of a static machine, but this is not the author's practice. Vacuum tubes may also be used with an interrupter consisting of from 30 to 50 small brass balls separated about one-quarter of an inch, secured

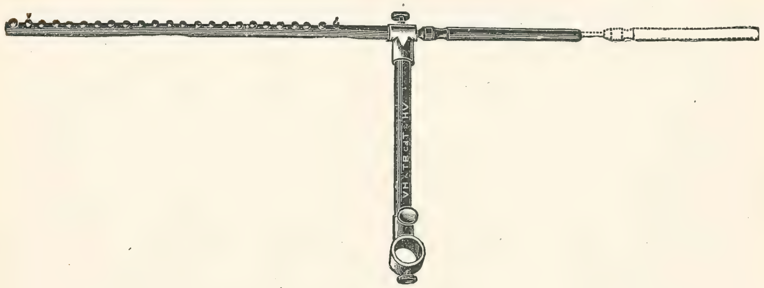

Fig. 40.—Interrupter.

to some non-conducting base (this is very apt to be made of hard rubber, but it becomes heated, and may actually melt, as it were, under the heat generated). This results in a distortion of the rod which renders it unfit for further use. Mica with a combination of shellac is recommended. This mechanism is provided with a sliding rod, which may be moved backwards and forwards, as is desired, thereby increasing or decreasing the number of spark gaps in the circuit. Fig. 40 shows one of these interrupters. This is usually known as the Files Interrupter. By the use of this multiple spark gap, the intensity of the discharge through

the tube is increased. Fig. 41 shows vacuum tubes with leading-in wires (1) for surface contacts, (2) for aural, and (3) for nasal applications. These the author has used daily

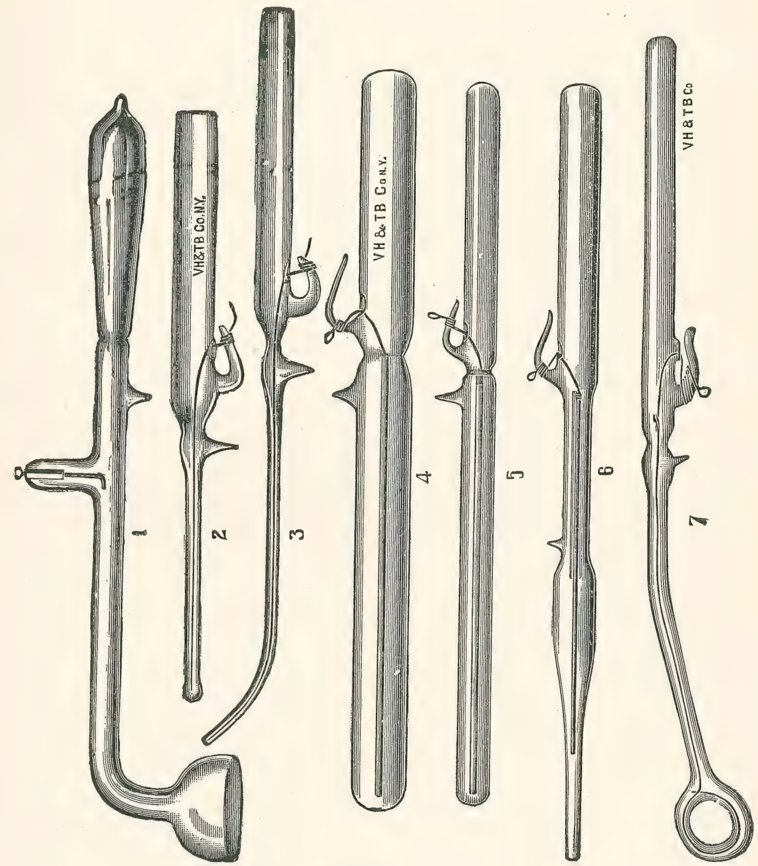

Fig. 41.

for a number of years as well as tubes constructed on similar principles for the vagina-rectum, uterus, urethra, and for tonsilar applications Nos. 4, 5, 6 and 7 of the same figure. Fig. 42 shows a set of vacuum tube electrodes of many different shapes without leading-in wires.

Many of these were devised by Dr. Snow, and they present many points of practical value. Especially is this the case where the part of the tube desired for localization, post nasal, for example, is the seat of the vacuum only, being sealed off from the length of the tube. These permit of

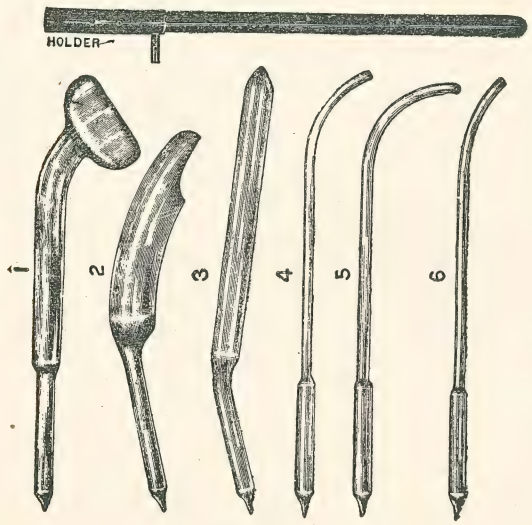

Fig. 42.

application to the ear and nose, both anteriorly and posteriorly, to the tonsil, cervix uteri, rectum, urethra, etc., without producing the sensation of the electrical discharge at any point save at the exact point where localization is desired.

Negative Terminal Richest in Chemically Active Energy.—As the terminal of the negative discharging rod is the seat of the most intense chemically active energy, connection should always be made with it. The object to be obtained is the production of light of as short and high frequency of vibration as the generating source can achieve. But under no circumstances is this ever ultra-violet energy outside of the tube. It is that of the longer waves of the

blue-violet region. These are very active chemically, and produce an image on photographic paper by their own light in a few seconds, almost instantaneously, at a distance of 2 to 3 inches, as the author has shown experimentally.

The negative brush of a Geissler tube is a source of intense chemical activity, and the rays are very pure violet. In an experimental study of these tubes some two years since, Leduc attributed the chemical effects largely to ultra-violet rays. It must be remembered that even though ultra-violet energy is generated in vacuum tubes, that it does not pass external to the tube in less than waves of 30 micro-centimetres. It does not follow, however, that there is not a strong chemical action from the blue-violet frequencies to which the glass is transparent.

Leduc[1] found that the light emitted from the negative brush of a Geissler tube exercises at a distance of several metres an intense photographic action upon one of the least sensitive of the bromid-of-silver papers, as, for example, the velox. Upon the latter an instantaneous impression is made at a distance of several centimetres. This fact the experimenter can easily prove by placing the source of the rays in front of a blackened chamber, the wall of which is pierced with a hole by a needle. In 30 seconds an image of the same, enlarged four times, can be obtained on a gelatino-bromid plate at a distance of 0.8 m. from the wall. In the same manner there may be obtained, with equal facility, negatives directly upon the paper. A bario-platino-cyanid screen may be substituted for the photographic surface, and a beautiful fluorescent image obtained.

A great deal of energy employed is transformed into the chemical activities, as the negative brush of a Geissler tube does not produce luminous or heat rays. There is no emission of the chemical rays from the positive terminal. In order to intercept the other rays Leduc enveloped the fluorescent part of the tube in black cardboard. A photograph of

[1]Revue Internationale d'Électrothérapie, Feb., 1902.

the entire tube showed that the middle part emitted many of the photographic rays. A photograph of the negative brush showed the emission of the chemical rays at that point. This phenomenon is analogous to that which has been studied with electric points in air at atmospheric pressure. The rays of the negative brush of the Geissler tube, identical with the violet rays of the spectrum are reflected, refracted and polarized; the beams can, therefore, be concentrated by lenses or mirrors or scattered by prisms.

On the strength of Leduc's observations. Colombo[1] very carefully investigated the therapeutic merits of Geissler tubes as a source of chemically active light energy. Of a series of cases treated, he reported in detail, three of lupus vulgaris treated by Geissler tube light. They had respectively 36, 65 and 76 exposures of from 15 to 20 minutes each daily, with absolutely no effect upon the lupus patches. The light energy of vacuum tube discharges is neither sufficiently complex nor intense to establish the tissue reaction necessary for the purpose of controlling lesions so deep seated and well organized. The same is true of all medical vacuum tubes. But it does not follow that they are valueless. They are of great value, and meet most satisfactorily the more recent congestions and inflammations. In conditions of circulatory stasis they act promptly. The brush discharge in vacuo may be used to an advantage in the early stages of inflammatory processes, incipient abscesses, for example; in sprains and contusions they also serve to relieve congestion due to the injury, and in that way favor prompt resolution.

The author has found them to serve an excellent purpose in the chronic catarrhal conditions so commonly found in all classes of cases. Intra-nasal applications three times a week for five minutes to each naris have relieved the congestions, lessened the thickening and discharge in hypertrophic cases, the scabbing and crusting in atrophic cases, establishing freer nasal respiration. Post-nasal dropping is

[1]Medical Electrology and Radiology, Oct., 1902.

also markedly modified, and the state of many of these patients very much improved, more so than by the classic measures. In a case of acute catarrhal cold supervening upon a chronic smoker's throat, and associated with severe asthmatic attacks, the asthmatic condition was so grave as to prevent dorsal decubitus. Sneezing was constant, nasal respiration impeded, mouth breathing, increased secretion, nasal and post nasal, enlarged and congested uvula, with strangling. The patient had not slept for several nights, and did not dare lie down because of the choking and asthmatic condition. A single intra-nasal application of the vacuum tube discharge, five minutes to each naris, also post-nasal application to the degree of toleration in time, followed by an application to skin surface of throat, especially over the region of the tonsils and uvula, resulted in so complete an amelioration of all the symptoms that the patient passed a comfortable night. Respiration, nasal and bronchial, was free, discharge was lessened, sneezing arrested, and asthmatic attacks controlled. This relief must be regarded as symptomatic only, but symptomatic relief under such circumstances is more than worth while. If successive applications are made over a period of time, nutritive changes will be established, which, in conjunction with appropriate hygiene, will do much to prevent the recurrence of similar conditions.

In the author's experience these vacuum tube discharges have rendered excellent service in the treatment of chronic catarrhal deafness, i.e., in modifying the degree of deafness. The accompanying tinnitus has also been relieved to a very considerable extent. The small aural electrode shown in Fig. 41 has been used for this purpose, its distal end being placed within the external canal and applications made for from 3 to 5 minutes each daily to every other day and less frequently in the latter part of the treatment. This has been supplemented by the use of a surface vacuum tube electrode, applied directly over the mastoid region for from 5 to 10 minutes each.

In the event of a chronically congested condition of the mucous membranes of the throat, an application is either made directly to them by means of a suitable tube, the one shown in Fig. 41 for tonsilar applications or with a surface electrode to the external surface over the tonsils and in the median line opposite the pharyngeal mucous membrane. For these purposes the author prefers the tubes with the leading-in wires because of the greater and more uniform distribution of the electrical discharge. Undoubtedly there is an action as well from the blue-violet frequencies of light.

At the same time that these vacuum tube discharges favorably modify chronic catarrhal conditions, the author has not found them of as great value as local applications, intra-nasal, tonsilar or aural, of the continuous current, negative—by means of suitable metallic contacts or with water as the electrolyte or by the use of oxidizable metals at the anode.

But for the more acute and recent processes the vacuum tube discharges are indicated primarily. In a case with a very considerable enlargement of the left parotid gland, following parotiditis, a single application by means of a surface vacuum tube electrode resulted in almost complete disappearance of the enlargement. This was unquestionably due to the establishment of circulatory drainage. The gland enlarged subsequently but to much less extent and was completely relieved. The many different uses to which these discharges can be put by suitably shaped contacts will suggest themselves to the individual practitioner.

CHAPTER XVIII.

N Rays. Their Place in the Spectrum and Relation to the Living Organism. Blondlot and Charpentier.

N Rays.

A discussion of light energy in its manifold phenomena in relation to life will not be complete without considering the living organism as an emissive as well as an absorptive agent. All bodies give out rays and it would be strange if the animal organism were an exception.

Some eighteen months since, there was discovered by the distinguished physicist, M. Blondlot, a new kind of light to which he gives the name of N rays, in honor of the University of Nancy, where the work was carried out.

These rays are not yet accepted by physicists as an undoubted scientific fact. Blondlot has found a probable explanation of the failure of many other physicists to repeat his observations. It lies in the fact that the emission of light is affected by N rays in the sense of being concentrated upon the normal rather than upon the tangent plane. Thus an observer watching the surface perpendicularly sees it brighten up; while if he watches it along the edge it appears to become duller. In the case of N rays the reverse is the case.[1]

There is, however, an accumulation of considerable data on the part of different experimenters which seems to point conclusively to the correctness of Blondlot's original observation.

Blondlot isolated these rays first from the Roentgen rays

[1]Comptes Rendus, February 29.

in the complex light emanating from a Crookes tube. Subsequently he demonstrated their existence in incandescent bodies such as the Auer mantle, the Nernst filament and even the solar rays. He has shown that every body in a state of molecular strain is a source of N rays and also in an almost indefinite fashion certain bodies in a state of constrained equilibrium, as tempered steel or glass for example; while the same is true of bodies which change their molecular equilibrium transiently, as a rod of bamboo when bent or a plate glass when being curved. The tempered blade of a Gallo-Roman knife emits them as well as modern steel. Because of these conditions as observed by M. Blondlot, he finds them comparable with the emission from uranium and radium.

N Rays Physiologically as well as Physically Important. —Blondlot also discovered that the N rays act upon the retina, increasing acuteness of vision. From the suggestions made to Blondlot by Charpentier (University of Nancy), whose experiments from the physiological side will be considered later on, he conceived the idea of trying if the compression of wood, of caoutchouc, and of glass would not provoke an emission of rays. At once he recognized that there was an emission during the time that the compression lasted. Similarly, upon bending a piece of wood the same phenomenon takes place and simultaneously the movement of the clock dial used for testing their presence can be more clearly seen.

This led to the further observation that the emission from tempered steel and tempered glass in a condition of constrained molecular equilibrium by reason of the process of tempering, was permanent. This emission appeared indefinite. The tools coming from the Merovingian epoch continued to emit the N rays at the level of the tempered parts.

Macé de Lépinay thinks that during musical vibration in such instruments as the tuning fork or siren, these rays are given out apart from the molecular strain. According to Jegou they are given out during the passage of a current in an electric wire. Lambert has found that soluble ferments emit N rays, especially the ferments concerned in the digestion of albuminoid matter. Meyer has found that plants emit N rays whether they are kept in the dark or exposed to light, and that there is no difference due to the action of light.[1]

Meyer has discovered some new sources of the extinguishing rays called by Blondlot N rays, and has obtained rays of a higher penetrating power than heretofore. If a screen with patches of phosphorescent calcium sulphid is placed in the receiver of an air pump and the pump is worked, the phosphorescence decreases, being restored as soon as the pressure is restored. The same thing happens if the screen is placed outside instead of inside the receiver. An incandescent lamp through which no current passes or a vacuum tube, are powerful sources of N rays, the strain of the glass under the atmospheric pressure being sufficient to account for their production.[2]

Place of N Rays in the Spectrum.—At first the N rays were placed at the infra-red end of the spectrum below the heat and near to the electric waves; more recently evidence points to their belonging to the violet end, their mean wave length being something like one-tenth that of extreme violet light. Blondlot has observed that these rays are not all of one kind and has also distinguished N^1 rays. Assuming their existence, the N rays, wherever they belong, are of interest as showing that there are more rays yet to be discovered and gaps to be filled in.

Screens to Facilitate Observation of N Rays.—For this purpose there is placed between the eye and the source of N rays a screen of pure blue glass, which Blondlot obtained by superimposing two special glasses, both blue, but of different spectral composition.

According to Charpentier, the following method of observing the physiological radiations, i.e., from living animals

[1]Comptes Rendus, Feb. 29, 1904.
[2]Comptes Rendus, April 11, 1904.

and the human organism, is the most simple: Place upon a black card a layer of collodion for adhesive purposes and then cover it with a quantity of phosphorescent sulphid. The sulphid should be spread out so as to form a spot 2 cm. in breadth and enough used to give a thin layer. It should then be exposed to sunlight and observed in a place more or less dark, according to the light it presents. Several minutes are necessary for the eye to adapt itself to this relative obscurity. The card thus prepared must be regarded with an indirect vision and without too much attention, just as the phosphorescent gleam of a tube of radium must be observed when placed in a dark closet, for example. The variations of light are produced gradually, which depend above all, upon the thickness of the sulphid. To this end the latter should be placed as thinly as possible on the collodion treated black card.

Aluminum Arrests the Nervous Rays.—A plate of half a millimetre, Charpentier found sufficient to obscure in an appreciable fashion the N rays given off by a portion of the brain. Additional thicknesses of aluminum, even one or two cm., does not interfere with the penetration of such rays as pass the thinner aluminum screen. The N rays given off by the heart, the diaphragm or different muscles are not modified, or so slightly as to be of no importance by the aluminum plate.

Characteristics of N Rays.—In common with other forms of radiation N rays have varying degrees of penetrability. They are absorbed by some substances and transmitted by others. N rays are arrested in great part by lead, water and moistened paper. According to Bichat, N rays act differently when bodies are placed in their path, and he has shown a possibility of selective absorption by different metals. They pass easily through aluminum, black paper, wood and saline water. These rays are, in common with luminous rays, capable of being reflected; likewise they have the properties of refraction, interference and polarization. The index of refractions has been determined by means of aluminum prisms. Blondlot observed that the index of quartz for these rays is about 2. He, therefore, compared them with the rays of Rubens, those remaining from filtration through rock salt, for which the index is 2.18. Charpentier states that he has obtained true foci, manifested by maxima of brightness, by converging lenses of glass. He found the index of refraction of rays given off by the body the same as observed by Blondlot for the rays given off by different substances. These rays can also be polarized. Blondlot observed that the N rays emitted by a Crookes tube, and filtered by a sheet of aluminum or a black paper presented rectilinear polarization. Their plane of polarization is deviable by a plate of quartz or a piece of sugar. A plate of mica set so that its axis made an angle of 45° with the plane of action of the rays destroyed the rectilinear polarization. This shows the double refraction.[1] Bagard has succeeded in reproducing the rotation of the plane of polarization in a magnetic field which was first produced by Faraday in the case of ordinary plane polarized light, and is usually shown as the Faraday effect. Since ordinary light consists of waves about 100 times as long as those which make up N rays, and since, according to Faraday, the rotation increases as the waves become smaller, it was natural to expect the Faraday effect to be very large in the latter. This has been fully verified by Bagard, who obtained rotations in aluminum and in carbon bisulphid, such as can with ordinary light only be obtained in quartz.

Blondlot has found that besides the kind of N rays already described, there exists another kind which reduces the luminosity of a feebly luminous surface instead of increasing it.[2] These are N^1 rays.

Gutton has found that the effect produced by N rays upon a luminescent screen may be imitated by means of a non-uniform magnetic field.[3]

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[1]Comptes Rendus, Feb. 29, 1904.
[2]Comptes Rendus, Jan. 25, Feb. 1, 1904.
[3]Comptes Rendus, Feb. 29, 1904.

Some substances seem to have the power of accumulating or storing up N rays. Bodies placed in sunshine, Blondlot has observed, seem to possess the property of storing these rays. Charpentier raised the question as to whether the human body really emitted these rays or whether it only stored them during the day or in the light in the fashion of the bodies exposed to sunlight by Blondlot. After a night's rest of nine hours in the dark, the phenomena were presented in the same fashion, the observations even being more readily made because of the more perfect adaptation of the rested eye. They were observed not only near the skin but at a distance as well. The nearer, the greater intensity, however.

The luminescence of phosphorescent bodies is increased by the action of these rays.[1]

They are said to have the power to increase in length the electric spark, and Blondlot has described a photographic method of recording changes in the electrical phenomena and brightness of phosphorescence. Charpentier seems to think that they may be transmitted through a metal wire, and excite phosphorescence upon a suitable screen at the other end of it, but he considers that these are probably not ordinary N rays, and Bichat thinks that the conduction through a wire is much the same as that of light waves passed through a curved glass rod.

Effect upon the Retina.—The N rays seem to act upon the retina and visual acuteness is increased by them. When looking upon an object in semi-darkness it is possible to distinguish the details very vaguely, but if there is directed upon the globe of the eye a "sheaf" of N rays the object is more clearly seen. Blondlot in his experiments with a clock dial placed at 4 metres, which gave only the impression of a gray spot, observed that by directing to his eyes a source of N rays, the details of the dial, figures, etc., were clearly visible. Upon removing the source of N rays the dial again

[1]Comptes Rendus, Jan. 25, Feb. 1, 1904.

became but a gray spot. In connection with this observation, Charpentier observes that the result may appear surprising when it is remembered that water even of little depth arrests them. But as water with the addition of a little salt permits of their passage, he finds in the salinity of the fluids of the body a reason for their transmission. It was observed in this experiment that it mattered little that the incidence of the N rays differed much or little from that of the visual rays going from the eye to the object observed.

N Rays from the Human Body.—The observations and reports from Charpentier have increased medical interest in the physiology of the subject. He states that rays similar to the Blondlot rays are given out from the human body during muscular and nervous excitement. The rays thus produced increase phosphorescence, the length of the spark of a coil, the passage through certain solid bodies, and the reflection, refraction, and index of the latter seem to be the same as N rays. Absolute darkness, according to Charpentier, is essential for some observers, while others require relative darkness only, and the screen should be excited first in order to see if there is an increase of phosphorescence during the application of the N rays. Charpentier, in his observations upon living organisms, used screens of platinocyanid of barium, regulating the luminous intensity by the aid of a salt of radium covered with a black paper, and placed at a variable distance. It is simpler, however, to use phosphorescent sulphid of calcium, moderately acted upon by the sun, as described under screens.

Augmentation of the Phosphorescent Light.—In order to clearly observe the increased luminosity of the phosphorescent screen a preliminary education of the eye is necessary. To this end a sufficient repose of the organ is advised. Complete darkness is not always necessary, that depends upon the luminescence of the object. This is governed by the power of the emitted rays. Charpentier states that the phosphorescent or fluorescent object increases in luminous intensity as it approaches the body, and that this augmen-

tation was greater in the vicinity of a muscle, increasing as the muscle was strongly contracted. The same was observed with a nerve or a nervous centre, the effect increasing with the function of the nerve.

Charpentier was able to follow in this way the course of a superficial nerve (a very delicate observation he states), as, for example, the median nerve, cubital nerve and various filaments near the skin.

Charpentier concluded from his observations that the human body emits N rays, and that the tissues whose functioning is most intense emit them in the greatest quantity. In this condition, he notes, is to be found a new method for the study of muscular and nervous activity. This he regards as important, especially so far as the external reactions of the nervous system are concerned, for at present the means of appreciating its effects are only secondarily by muscular contraction and sensation. He also finds in these conditions the base of a new method of clinical observation. The area of the heart, a muscular organ in almost continued activity, can by careful observation be determined by a small luminescent object carried around the cardiac region near the cutaneous surface. By the changes in its brightness the limit and the surface of the projection of this organ can be observed. It is suggested also that by the aid of the N rays the position of the muscles may be determined, the peristaltic movements of the stomach, liver and diaphragm, as well as the heart, as muscular activity is a feature of all these functioning organs. The possibility of studying the exterior outline of the nervous centres is also predicted by Charpentier.

Effects of N Rays upon the Cerebrum and upon Reaction of the Pupil.—Charpentier has discovered two new effects of N rays. If a strong source of N rays is placed 4 cm. behind the top of the skull and a little above it, not only are faintly luminous objects perceived with greater brightness and detail, but in absolute obscurity a faint luminous cloud is perceived. The other new effect is the enlargement of the

pupil when the condensing plate is placed over the seventh cervical vetebra.[1]

Emission of N Rays by the Lower Animals.—(1) The emission of rays by living organisms is not a phenomenon peculiar to man. It presents itself as well in the various animals usually found in laboratories, from which it may be concluded that it is a phenomenon characteristic of the lower animals. With these animals as with man it is the muscles and nerves which form the principal source of the radiation, and this is greater when they are in a state of functional activity. (2) As it was possible to maintain the frog at the time the experiments were made (December and January), at a temperature sensibly lower than that of the air of the laboratory, between 0° and 10°, for example, Charpentier found it possible to show that the increase of phosphorescence in his experiments was not due to rise of temperature. He found under the conditions indicated that the general laws of the phenomenon remained unmodified. Even when the phosphorescent object is first treated to a temperature higher than that of the body, 40°C. or a little less, thereby increasing its luminosity, it would still be observed in the neighborhood of muscles, nerves and nerve centres to increase in luminosity. This becomes still more intense if these organs are functioning. Charpentier observed that under the influence of the light of the electric spark, from both the primary and secondary of induction coils, i.e., ultraviolet light, these radiations were increased.

Distinction Between Nerve and Muscle Radiation.—To answer this question Charpentier made some observations on a curarized frog by which he established the fact that muscle radiates by itself, but less than the nerve. He observed that when the faradic excitation of the motor nerve or of its peripheric end is not efficacious in producing muscular contraction, still the emission of N rays was observed by the action upon the phosphorescent screen. Charpentier

[1] Comptes Rendus, Jan. 25 et Fév. 1, 1904.

regarded it as proof that in curarization, the terminal or peripheric filaments of the nerves can be placed in a state of excitation and that in the muscular emission of N rays the terminations of the nerve take part at the very last in the phenomena. In the second place the cuarized muscle was directly excited. It contracts and gives out N rays. This does not seem to be more than the excitation of the peripheral nerve endings and Charpentier suggests that the emission of the N rays could very well in this instance be due to excitation of the intra-muscular filaments. The day following the experiments the frog was dead and his gastrocnemius was found inexcitable even by a strong faradic current. There was no appreciable augmentation near the muscle. On the contrary, the excitation of the peripheric end of the nerve although ineffective gave place to an increased phosphorescence against the muscle. From this the inference is drawn that in the emission of N ray by muscle, the excitation of nerve terminations intervenes for the most part, but that probably that of the muscular substance intervenes also and more feebly. This is not regarded as a certain conclusion. Of this fact, however, Charpentier was convinced that there was a proper radiation from muscle. The radiation between muscle and nerve was differentiated by the observation that the nerve increases its radiation notably under the influence of the lightest compression.

Charpentier with his colleague Professor E. Meyer made this observation upon the spinal column and nerve roots of a dog. Compression does not so markedly influence muscle radiations. By the radiations, Charpentier found it possible to distinguish the presence of nerves upon a part of the body and also to appreciate their contributory part in the total radiation coming from an organ. The nerve radiation produces stronger phosphorescence, compared with the radiation of other tissues, upon the phosphorescent sulphid when heated near 40° or 45°C.

From these observations as to the difference between the radiations of different tissues Charpentier concludes that the nerve radiation differs more than that of any other part of the body from the pure Blondlot rays.

Relation to Temperature.—The rays are not due to an increase of temperature in the vicinity of the skin, for they persist even when many layers of aluminum or of cardboard, separated by layers of air, forming a calorific screen, are interposed. And again, they cannot be the result of heat, because of their immediate development, i.e., a few seconds, whereas the effect of heat taken much longer; moreover Charpentier is satisfied that similar rays are emitted from animals, such as the frog, which may be kept at a temperature from 0° to 10° below the air.

The Effect of N Rays upon Phosphorescent Bacteria.—The phosphorescence of bacteria is augmented by them. During the summer of 1903, Charpentier observed that the luminescence of the glow worm increased upon exposure to N radiations from the sun. He also observed that cultures of phosphorescent bacilli, photobacterium and phosphobacterium italicum responded in the same manner to the radiations from the heart, the muscles and the nerves as did the sulphid of calcium screen. Phosphorescence diminishes with bacilli when the temperature rises above 25° or 30°C., and even less.

N Rays Given Out by Muscles in Contraction and Nerves under Compression.—They are not only given out by muscles in contraction, but compressions of nerves give the best results. Charpentier selects certain regions, such as the spinal cord over the cervical and lumbar regions, for special demonstrations. The entire tract of the spinal cord was found to increase the phosphorescence of the screen, opposite the nearest external part. For instance, opposite the cervical and lumbar enlargement the radiation is stronger and more extended. Upon contraction of the arm of the subject under observation, the brightness of the screen augments at the cervical enlargement. There is an increase in the brightness on passing up the cord to the neck. If the contraction of the arm is only unilateral the illumination is more marked on the

same side of the cervical region at first, while toward the upper part of the cord it goes to the opposite side, to the left, for example, if the right arm has been contracted. The localization of this increased luminosity to the left is a little variable, but is generally situated low down in the bulb.

For his experiments, Charpentier used straight tubes of lead 5 to 10 cm. long. One extremity is placed against the body; the other contains inside a little washer of cork or cardboard covered with phosphorescent sulphid. Glass tubes as well as tubes of metals have been used. The emitted rays in "pencils" as far as possible must follow the light of the tube. Large screens cannot be utilized because each part of the sulphid is influenced by the others, and the ensemble gives a light of uniform appearance in function with the total mass of the rays which meet the screen. Difficulties will be encountered in localizations deep in the body by reason of the different properties of the superimposed tissues.

Muscles in Contraction as a Source of N Rays.—As solids subjected to mechanical constraint emit N rays Charpentier sought for them in tendons during muscular contraction, a condition analogous to the strain in inanimate substances. His observations were made on the tendo Achillis and on the tendon of the extensor of the great toe as well as other tendons. There was no increase of the luminescence of the excited screen, no matter how powerful the contractions were. He observed, however, that the points of insertion and the osseous parts glowed under the influence of muscular activity. This he attributed to the fact that the tendons themselves were very poor in nerves while the preceding points are rich in terminal nerves whose compression would suffice to explain the phenomena of radiation. This radiation was arrested in this locality by aluminum as well as elsewhere.

The compression of a nerve, though light, increases the luminescence notably either above or below the point compressed. Prolonged compression causes the radiation gradually to diminish.

N Rays Emitted by the Brain During Activity.—Charpentier also observed that central convulsions, such as Broca's, show an augmentation of the luminosity while one is speaking. Other centres of brain are said to act similarly. This centre was precisely localized as by the surgeon for operative purposes. The subject of the experiment then spoke either loud or low, the excited screen being moved over the side of the cranial case. The luminosity increased on the left in the region near this centre, presenting a maximum which corresponds within the limits of 1 to 2 cm. to the point of the sulcus, known clinically. Nothing parallel is observed on the right side. A slight increase of brightness was observed opposite the convolution of Broca, arising from the centre opposite or from deeper centres interested in vocalization. In pointing the tube obliquely so as to aim only at the centre of Broca, the radiation becomes very feeble or is wanting. Similar radiations were observed during the functioning of other motor areas, each responding in its proper zone to the act of writing, movements of upper extremities, etc. Excitation of sensitive nerves gave rise to the same phenomena. The conclusion was therefore reached that every nervous centre when functioning increases its emission of radiation in repose, in proportion to the degree of activity. These rays are divergent as they are transmitted, following the law of optics, and they traverse with more or less refraction successive media.

N Rays in Relation to Mental Effort.—This was also made the subject of experiment, and it was found that mental effort on the part of others as well as upon the observer himself sensibly increases the luminosity of the excited screen. In this instance the excited screen is placed upon the forehead. A condition of mental relaxation is secured so far as possible in the one instance and one of earnest thought, involving a calculation or process of reasoning, in the other. The difference observed in the luminosity though feeble, is plain, being the more marked in the subjects appreciating best the real significance of mental inertia and activity. All

marked effort of will or attention increased the radiation to an extent visible to outside observers. Violent effort is not necessary, simply a clear fixation of the will or attention upon the single thought.

If the subject formulates a wish, for example, that the screen may become brilliant, or expresses indifference to the matter, he may himself observe the effect upon the screen, or as Charpentier naively remarks, "Can see himself think." Variations of intensity of reflection and attention give corresponding variations of luminosity in the excited screen as it is moved over the forehead. Familiar subjects do not produce the effect of new and complicated subjects. It will be of great importance in this connection, Charpentier suggests, to prove that the will and the suggested idea as well can influence feebly but truly a physical phenomenon.

The N Rays as a Chemical Reagent.—In the further investigation of N rays, experiments have been made to determine what possible reaction the N rays may have as chemical reagents. Colson[1] is of the opinion that the N rays are capable of being utilized as a delicate chemical reagent of considerable value. Some chemical reactions are the source of N rays, while other and very similar ones are not. In preparing zinc hydrate the result is the same whether zinc sulphate is added to caustic potash solution or the latter is added to the former. But in the latter case, the reaction gives rise to N rays, which diminish the brightness of a phosphorescent screen, whereas the reverse process does not give rise to the rays. This evolution of rays is accompanied by the formation of a basic salt which is only formed as long as the zinc sulphid is in large excess. Calorimetric tests show that the formation of this basic salt gives rise to a greater quantity of heat than the formation of the zinc hydrate without such an intermediary stage.

N Rays Complex in Their Nature.—Lastly, Charpentier declares that the rays are complex in their nature and that

[1]Comptes Rendus, April 11, 1904.

filtration through different metals will result in different effects. The physiological radiations are N rays for the most part, but their composition seems more complex than those described by M. Blondlot, from which they differ in certain respects. Lead does not arrest them completely nor does pure water.

Possible Diagnostic Value.—Granted that the intensity of these radiations is proportioned to the functional activity of the nerve or muscle whence they emanate, Charpentier believes that there proceeds from these proofs a new method of investigation applicable to physiology (muscular and nervous activity) and even to clinical study. Notably, one can, with some attention, map out the area of the heart, an organ in almost continual muscular activity; for a little luminescent object moved near the skin in the cardiac region manifests by its changes of brightness the limit and the surface of projection of the organ studied. It is stated that an Edinburgh neurologist considers it possible that obscure brain tumors may be located by means of these rays.

Digitalis and the N Rays.—It has recently been observed by Jean Becquerel, son of the distinguished physicist Henri Becquerel, that digitalis, when placed near the functioning heart, emitted N rays to a visible degree, but not when alone.

The truth of this statement must be vouched for by the fact that it was reported by Henri Becquerel[1] to the French Academy of Sciences. If true it would indicate that the physical agency of drugs has been the most potent after all, not the chemical. The physical is back of the chemical throughout the varied phenomena in nature. Bacteria are agitated by short and high frequency vibrations of light energy and in the resulting chemical change they yield up their life. The author is disposed to believe that the physical action of drugs is paramount; that the vibration of strychnia molecules for example finds a response in the vibrations of anterior ganglion cells and so stimulates them. Energy is trans-

[1]Comptes Rendus.

ferred by wave movement and nerve impulses, cerebral or peripheral, are waves. The laws of transformation and conservation of energy hold good for the living being. Stimulus received at the periphery is transmitted to the interior. The answer comes in excitation of the motor apparatus and is revealed in movement and nutritional processes. It is but rational that the animal organism, which has been likened to "one gigantic neuron," should be affected primarily by the varying rates of vibrational activity of various drugs, as it is by other vibratory influences.

The most recent literature that has come to the author's attention places these rays at the violet end of the spectrum rather than at the opposite end between the infra-red and the shortest wave length Hertzian ray. To the author's mind this would seem the rational place for such rays if they really exist. As has been shown in this analysis of the work of Blondlot, Charpentier and others, their most important characteristics are (1) high refrangibility, (2) great penetration, (3) luminescent excitation. They increase phosphorescence but do not initiate it. They can be reflected, refracted, polarized and brought to a definite focus like light rays but differ from them in their ability to penetrate aluminum, black paper and most substances transparent to Roentgen rays. They are not regarded in the least as ions, electrons, effluvia, auræ or other particular emanations.

Remarks Based upon their Supposed Position at the Lower End of the Spectrum.—If N rays exist, still doubted by many able physicists, they will help to bridge over the gulf between electrical action and radiant energy. Their study will, it is said, be a revelation in the general theory of radiation, and their unusual properties serve to broaden the current conceptions of transparency and opacity as well as the view of the interrelations between radiant energy and electrical action. Blondlot's discovery is regarded as of peculiar value in the fact that it deals with things which have a direct and comprehensible and even unclassified relation to the general theory of radiant energy.

There is a belief on the part of some that they are complementary to the "dark rays" which Gustave de Bon discovered proceeding from the unilluminated surface of thin opaque metallic plates exposed to the action of ordinary light. If this be true it would appear that certain ethereal vibrations beyond the two ends of the visible spectrum exhibit similar powers of penetration, those at the ultraviolet end being in addition photo-chemically active.

In their relation to organic substances, and especially the human organism, these rays, if they really exist, as so convincingly set forth by Charpentier in his experimental observations, open up a wonderful field for research, which, if fully covered, will doubtless illumine many hitherto not understood and curious phenomena.

"The degree to which the phenomena are manifested is co-relative to the character of the idio-muscular contractions, being proportionate to their rapidity and energy. The same is to a less extent noticeable in inanimate bodies, in which the processes of natural resolution into simpler compounds are retarded by artificial means. These discoveries afford a rational explanation of the 'Corpse Lights' said to have been noticed on opening up ancient graves, and of 'Od' force so widely discussed in the early Eighties."[1] These observations of Blondlot have been substantiated by Walsham and Leslie Miller of London. They state that they have been able to pass the rays through books and to discriminate between the results obtained when the muscle is in action and when it rests by the physical results or changes produced in the photographic plate. On the other hand, Schenk, Burke, McKenrick, and Campbell Swinton, have not been able to confirm the observations of Charpentier. That there is a truth in Charpentier's observations the author is prepared to believe. The reported increase of fluorescence upon the excited screen, as the result of mental effort, finds its counterpart in the movement of the light beam of the mirror galvanometer when placed in circuit with the subject.

[1]Editorial, Med. Electrology and Radiology, March, 1904.

Under date of August 26, 1904, comes the report that the Paris Academy of Sciences has awarded the Lecomte prize of 50,000 francs to Blondlot for his brilliant researches into this subject. As the opinion of this body carries considerable weight, there is less reason for questioning Blondlot's discovery or the existence of N rays.

CHAPTER XIX.

Alpha, Beta and Gamma Rays of Radio-Active Substances. Uranium, Thorium, Polonium, Actinium and Radium. Radium: Its Physics, Physiological Action and Therapeutic Value. Prof. and Mme. Curie.

Radium.

Perhaps of all the various manifestations of the energy of oscillating light corpuscles, the greatest mystery is the source of the ceaseless energy which is emitted by radium, the highest form of etheric vibration.

"The answer will probably be found in those vibrations of ultimate matter which are transmitted throughout space, which, as Duncan has said, is all 'a-quiver with the waves of radiant energy,' ranging from the infinitely short to the incomprehensibly long; the rays which most interest us being the exceedingly short while the waves of great length corresponding to the sound waves of the organ diapason are the waves of Hertz and Marconi, equally mysterious, but concerning us less at this time and place."

The electro-therapeutist with his high frequency discharges from vacuum tubes, his ultra-violet rays, his cathode and X ray must of necessity have not only a scientific but a practical interest as well in radio-activity.

Radium, polonium, uranium, actinium and thorium form a group of radio-active metals which have been extensively experimented with and studied by Professors Becquerel, Thomson, Rutherford, Brookes, Lodge, Laborde, Ramsay and Professor and Madame Curie.

With radium, polonium, actinium and thorium, light is given off the moment they are created, without having to be stimulated by any source of heat, light, electricity or any other form of energy so far as is at present known.

A vast amount of speculation and some interesting hypotheses have been evolved to explain the phenomena observed in experimenting with these substances. Much has been learned from them "about the constitution of matter and the correlation of the vital and physical forces, more in all probability than any substances which have been created since the world began."

Becquerel Rays.—Following upon the investigations into the phenomena produced on the interior and exterior of various kinds of vacuum tubes to which great importance must be attached, i.e., the Roentgen rays, and also the photographic effects produced by phosphorescent and fluorescent substances, came the discovery in 1896 of M. Henri Becquerel of the radiations emanating from uranium, and which are known as Becquerel rays. The importance of Becquerel's discovery of radio-activity can hardly be overestimated.

The question arose as to whether, if the emission of Roentgen rays did not necessarily accompany the production of fluorescence, what was the cause of the latter.

M. Henri Poincaré[1] was the first to attempt an elucidation of this problem. Following his announcement that he had obtained photographic impressions through black paper by the aid of phosphorescent sulphid of zinc,[2] was the statement of M. Niewenglowski[3] that he had obtained the same phenomenon with sulphid of calcium exposed to light. Strong photographic impressions with phosphorescent artificial hexagonal blend acting through black paper and a thick cardboard were finally obtained by M. Troost.[4]

[1]Rev. Gen. des Sc. 30, Jan., 1896.
[2]C. R. t. CXXII., p. 312.
[3]C. R. t. CXXII., p. 386.
[4]Ibid., p. 564—all quoted by Mme. Curie.

M. Becquerel followed with his studies upon uranium. He obtained photographic impressions through black paper with the double salt of uranyl and potassium. The first thought entertained was that the phenomena were due to fluorescence, but this was soon refuted. It was not necessary that the salt should glow to produce photographic impressions. In the author's experience, for example, a specimen of German radium, estimated to have a radio-activity of 40,000 which had a most brilliant phosphorescent glow, far in excess of that of a specimen of French radium having a radio-activity of 7,000, gave an absolutely negative result photographically for a 45-minute exposure, while with the latter, a 20 and 30-minute exposure gave a fair imprint. All the compounds of uranium, whether fluorescent or not, act the same and the most active of all is metallic uranium. Becquerel proved that these rays traversed thin metallic screens, discharged electrified bodies, and could be reflected, refracted and polarized. Becquerel's observations were confirmed and further investigated by Elster and Geitel, Lord Kelvin, Schmidt, Rutherford, Beattie and Smoluchowsky in every particular save in so far as the reflection, refraction and polarization of uranic rays were concerned. From this point of view they comport themselves as do Roentgen rays, as was first recognized by Rutherford, and subsequently by Becquerel himself.

Properties of Becquerel Rays.—These rays (1) impress photographic plates, (2) traverse liquids and solids if not too thick, (3) in traversing gases they render them feeble conductors of electricity. These properties are not due to any known exciting cause. The radiation seems spontaneous. When kept in the dark for years it does not diminish in intensity, as it is not a phosphorescence induced by light. Madame Curie measured the intensity of the radiation of uranium by utilizing the action of the radiation upon the conductibility of the air. Within the limits of precision of the experiment she has obtained numbers which prove the constancy of the radiation, i.e., to 2 for 100, or nearly 3 for

100. Becquerel rays are emitted by uranium and thorium. They differ from X rays in their penetrating power, in that the greater part of the radiation is arrested by a few mm. of solid matter, and cannot leap into the air for more than a few cm. Rutherford,[1] especially, but other physicists also have shown that they are not capable of reflection, refraction, nor polarization. The laws governing the conductivity of Becquerel rays through gases is the same as for Roentgen rays. The theory of the ionization of the gases by the effect of Roentgen rays, and Becquerel rays sufficiently explains the observed facts. This theory leads to the following results: (1) The number of ions produced per second in the gas is considered as proportional to the energy of the radiation absorbed by the gas. (2) To obtain the current limit relative to a given radiation, it is necessary, on the one hand, to cause this radiation to be absorbed wholly by the gas, employing a sufficient absorbent mass. On the other hand, it is necessary to utilize for the production of the current all the ions created, in establishing a strong, electrical field, for the number of ions which recombine becomes an insignificant fraction of the total number of ions produced in the same time, almost all of which are taken by the current and drawn to the electrodes.

According to Madame Curie, the radiations from thorium are more penetrating than those of uranium, and those from a thick layer of oxid of thorium are more penetrating than those from a thin layer. A practical point to be considered in using oxid of thorium for therapeutic purposes is the thickness of the layer.

Radio-Activity of Uranium and Thorium an Atomic Property.—From a study of a considerable number of compounds, Madame Curie has found that the property of radio-activity is dependent upon the presence of the atoms of the two elements considered. It can neither be destroyed by a change of physical state nor by chemical transformation.

[1]Phil. Mag., Jan., 1899.

Of all the substances examined in her search for radio-active substances, Madame Curie found that uranium and thorium bear the largest atomic weight, 240 and 232. These two substances are met frequently in the same minerals.[1]

In 1898, Professor Pierre Curie and Madame Sklodowska Curie, when investigating the radiations from uranium discovered by Becquerel, found that some samples of pitchblende or uranite, from which uranium is extracted, gave forth radiations much more powerful than any uranium they had found, having four times the activity of metallic uranium.

Painstaking research resulted in the discovery of a substance associated with bismuth, and resembling it very much in its chemical characteristics. To this substance Madame Curie gave the name of Polonium, in honor of Poland, the land of her nativity.

Polonium is to be had in the form of a metal and in the form of a sub-nitrate. The metallic polonium resembles particles of nickel and the sub-nitrate is a white powder.

In the year 1898, Professor and Madame Curie, in collaboration with M. Bemont, isolated a second substance from pitchblende, which was associated with barium and possessed many chemical and other characteristics of that substance. To this they gave the name of Radium. In 1899 Debierne discovered actinium. Gietel finds that polonium has both deviable and non-deviable rays and Elster states that when it is placed in a vacuum it is found to be deviable by a magnet to a much greater extent than radium. The rays from actinium are also deviable, while the rays from radium are reflected from a straight line, differing in that respect from the Roentgen or X ray.

The Radio-Activity of Uranium Used as a Standard of Comparison.—The radio-activity of uranium is taken as a standard of comparison and polonium of 300 radio-activity or radium of 7000 radio-activity, means that the one is 300 and the other 7000 times more powerful than the original

[1]Madame Curie, Recherches sur les Substances Radio-active.

radiations emanating from uranium or Becquerel rays, Radium, actinium and polonium have a million times the activity of uranium according to Professor Curie.

Radium a New Metal.—Professor Curie regards radium as distinctly a new metal; it has never been found, however, in a metallic form, but is to be had as a chlorid or bromid.

Sources of Radium.—Since the discovery of radium, its presence in various parts of the world has been exploited but not always with true regard for the actual facts. The chief source of pitchblende, from which radium is extracted, has thus far been the mines of Bohemia.

A Mine of Radium.—Sir William Ramsay affirmed before a learned society of London, that there existed in the very heart of that great city, of which the soil has been so often turned over and thrown open, a mine of radium of great richness. For a number of years there has existed (since the use of uranium has increased) a manufactory of this rare metal in London. All the residue coming from its extraction has been accumulated not far from the factory which is still in action, as a *caput mortuum,* the disposition of which is difficult. If it should be proven that the waste contains radium, as do other uranium minerals, it would be an exceedingly convenient and valuable source of this precious substance. It is some months since Sir William Ramsay made this statement, but the author is not advised as to the correctness of his prediction.

The discovery of extensive uranium mines in Utah by Mr. Lockwood is referred to by Madame Curie in her work on radio-active substances. She notes that there has been formed at Buffalo a society entitled "Welhs-Laftus Uranium and Rare Metal Co.," which proposes to treat daily two tons of mineral which will permit the obtaining of 100 pounds of oxid of uranium, 10,000 grains of a radium-barium substance, having an activity of 10 units, and 100 pounds of the other metallic residues, consisting principally of polonium. Whether the output of this mine equals the expectation indicated above is not known.

Quantity of Radium.—This is true, that there is but a very small quantity of radium salts to be had. A year since it was estimated by Professor Curie that the three years' work done both in Germany and in France had, a few months prior to that date, resulted in the production of but one pound of radium, including all grades and qualities. All radium of higher radio-activity than 7,000 was until within a year retained for the experiments of Professor and Madame Curie and their associates, in the laboratory.

Radium salts can now be obtained for experimental and therapeutic work from a number of importers of chemicals and electro-medical apparatus. The price doubled within a space of a few months in the beginning of the present year. It is difficult to obtain in any, save minute quantities, but it is possible to secure radium salts of higher radio-activity than one year since. It is not possible to depend always upon the degree of radio-activity as demonstrated in the instance referred to by the author, where a salt of 40,000 radio-activity, brilliantly phosphorescent, was exceeded in photographic activity by 7,000 radio-activity.

The Process of Extraction of Radium.—Radium is a substance which accompanies the barium extracted from pitchblende. In its reactions it follows barium and it is separated from it by the difference of solubility of its chlorids in water, alcohol water or water and chlorhydric acid. Polonium, actinium, and radium are found in absolutely infinitesimal quantities in pitchblende. In order to obtain them in a concentrated state, the Curies found it necessary to treat many tons of uranium residue.

In the process of extraction of radium, the gross extraction is done in a factory, then purification and concentration follows. From thousands of kilograms of matter there are thus extracted, first a few decigrams of extremely radio-active products in comparison with the original mineral. Radium is the only one among the new radio-active substances which has been isolated as a pure salt.

Atomic Weight of Radium.—This was obtained in the

classical manner by Madame Curie and found to be 225 and is the largest atomic weight of any known substance. The molecule is therefore very large.

The Spectrum of Radium.—This was determined by M. Demarçay. The first specimen of radio-active chlorid of barium examined by Demarçay showed him not only barium lines, but a new line of notable intensity and of wave length λ 381.47 $\mu\mu$ in the ultra-violet of the spectrum. Subsequently, with more active products it was noted that the 381 $\mu\mu$ was stronger and at the same time other new lines were observed. The new lines and the lines of barium were of comparable intensity. A new and more concentrated product showed the new spectrum predominating; the three strong lines of barium alone visible indicated the presence of that metal in a state of impurity. This product was regarded as a nearly pure chlorid of radium, but a more complete purification of it showed the two dominant barium lines but feebly.

The portion of the spectrum between 500 $\mu\mu$ and 350 $\mu\mu$ contains the principal radium lines. The intensity of each line is indicated by a number, the strongest being marked 16.

λ	Intensity.	λ	Intensity.
482.63	10	453.35	9
472.69	5	443.61	8
469.98	3	434.06	12
469.21	7	381.47	16
468.30	14	364.96	12
464.19	4		

All the lines are clear and straight, the lines 381.47, 468.30, and 434.06 are strong; they attain equality with the most intense lines actually known.

Two strong nebulous bands are also observed in the spectrum. The first of these is symmetrical, and extends from 463.10 to 462.19 with a maximum at 462.75. The second, which is stronger, becomes fainter toward the ultra-violet. It begins abruptly at λ 446.37, passes by maximum to λ 445.52. The region of the maximum extends even to 445.34; there is then a nebulous band gradually fading away

to 439. In the least refrangible part (not photographed) of the spark spectrum, the only line notable is the line about 565.5, very much more feeble than 482.63. The spectrum of radium is shown in the colored frontispiece. The general aspect of the spectrum is that of the alkaline earth metals, the spectra of which have strong lines with nebulous bands.

Demarçay finds that radium is one of the bodies having the most sensitive spectrum reaction.

In the first specimen examined which showed clearly 381.47, Madame Curie regarded the proportion of radium as very small, possibly 0.02 for 100. Notwithstanding this observation it is necessary to have an activity 50 times greater than that of metallic uranium to perceive clearly the principal line in the photographic spectra.

Radio-Activity More Sensitive than Spectrum Reaction. —The radio-activity of a product, when it is but 1/100 of that of metallic uranium, can be told with a sensitive electrometer. Radio-activity is therefore a thousand times more sensitive than the spectrum-reaction. Bismuth with polonium and thorium with actinium examined by Demarçay have given respectively only the lines of bismuth and of thorium. Giesel[1] finds that a preparation of the bromid of radium gives rise to a carmine coloration of flame. The spectrum of the flame of radium shows two beautiful red bands, one line in the blue-green and two feeble lines in the violet.

Characteristics of Radium Salts, Chlorid, *Azotate,* Carbonate and Sulphate.[2]—These salts of radium have the aspect of barium when fresh but all color with time. They are luminous in the dark. By their chemical properties they are absolutely analogous to the salts of barium. The salts of radium disengage heat spontaneously and continuously. The chlorid of radium is para-magnetic.

M. Curie and C. Chéneveau devised an apparatus by means of which they have measured the coefficient of

[1]Giesel, Phys. Zeitschrift, 15 September, 1902.
[2]Madame Curie.

chlorid of radium. This coefficient has been measured by comparison with that of water, and corrected for the magnetism of the air.

Radio-active chlorid of barium containing about 17 to 100 of chlorid of barium, is diamagnetic and possesses a specific coefficient.

Energy of Radiation (1) Photographically.—The energy of radiation of radium is considerably greater than that of uranium and thorium. With radium a photographic plate is acted upon instantly while an exposure of twenty-four hours is necessary for uranium and thorium.

(2) Fluorescence.—Radium on contact quickly illuminates a fluorescent screen. This is not true of uranium and thorium.

(3) Ionization.—Radium exerts a much greater ionizing action upon the air than uranium and thorium.

The total intensity of the radiation of radium is estimated by means of an electrometer but with more difficulty than that of uranium. With uranium the radiation is very nearly absorbed in the layer of air which separates the plates. It is not the same with more strongly radio-active substances. The radiation of radium is in part constituted of the very penetrating rays which traverse the condenser and metallic plates, and are not used to ionize the air between the plates. Nor, says Madame Curie, can the current limit always be obtained at the tensions, i.e., pressure, at one's disposal. For very active polonium, the current is still proportional to the tension, between 100 and 500 volts. The experimental conditions are such that there is not given to the measure a simple significance and in consequence the measures obtained cannot be considered as giving the measure of total radiation, and from this point of view they constitute only a gross approximation.

The following table from J. J. Thomson's work on "Conductivity of Electricity through Gases" shows the relative ionizing power of Roentgen, cathode, radium, polonium and uranium rays:

RELATIVE IONIZATIONS.

Gas.	Relative Density.	Roentgen Rays.		Cathode Rays.	Radium Rays.		Polonium Rays.		Uranium Rays.
		Thomson.	Perrin.		Penetrable Type.	Absorbable Type.	I.	II.	
Hydrogen	.0693	.33	.026	.069	.157	.218	.226	.219	.213
Air	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Oxygen	1.11	—	—	1.106	1.21	—	1.16	—	—
Hydrochloric acid	1.27	8.9	8.	—	1.46?	—	—	—	—
Carbonic acid	1.53	1.4	1.34	1.53	1.57	—	1.54	—	—
Cyanogen	1.86	1.05	—	—	1.86	—	1.94	—	—
Sulphur dioxid	2.19	6.4	6.	—	2.32	1.92	2.04	2.03	2.08
Chloroform	4.32	—	—	—	4.89	—	4.44	—	—
Methyl iodid	5.05	—	—	—	5.18	3.74	2.51	3.47	3.55
Carbon tetrachlorid	5.31	—	—	—	5.83	—	5.34	—	—

The following simple apparatus devised by Strutt[1] exhibits in a striking manner the dissipation of negative electricity from radium by the cathode rays evolved by it, and the accumulation of a positive charge. A glass tube, *a*, with thin walls, is hermetically sealed, and contains the radium preparation, as shown in the accompanying cut. It is suspended from above by the quartz rod, *b*, while from its lower end hang a pair of gold or aluminum rods, *c c*. The glass tube *a* is smeared over with a conducting coating of phosphoric acid, and the whole system hangs from the stopper, *d*, of the glass bulb, *f*. Strips of tin foil, *e e*, at the sides of the bulb are connected to earth. As long as there is air in the bulb no divergence of the leaves is observed, since the radium rays make this air a conductor. But if a good vacuum be made in the vessel, the leaves soon begin to diverge, owing to the loss of negative electricity by the radium. This divergence increases until the leaves touch the tin-foil strips. When this happens the leaves are discharged and collapse, and the cycle recommences. With a weak radium preparation, Strutt obtained a full divergence in about 20 hours. But with a more active preparation the cycle can be com-

[1]Elec. World and Engineer, April 9, 1904.

pleted in course of a lecture. The time in which the cycle is completed is, of course, an indication of the degree of radioactivity of the substance in *a*.

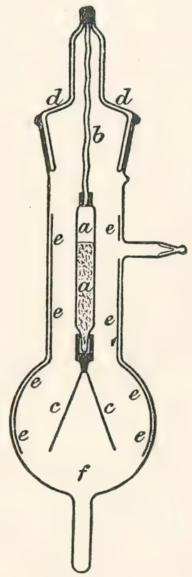

Fig. 43.—Apparatus for Demonstrating the Absorption of the Radium Radiations. Strutt.

A Modification of Strutt's Apparatus Demonstrating the Negative Charge of the β Radiations.—Paschen,[1] in an illustrated note, shows that the apparatus of Strutt for demonstrating the positive charge of radium enclosed in a glass tube, may be modified so as to demonstrate also the negative charge of the β radiation which penetrates the glass. As shown in the illustration, a glass bottle which may be evacuated contains the small glass tube *b*, which contains a radium-barium preparation, and is suspended by means of the quartz rod, *a*. Two quartz tubes, a_1 and a_1, hold the hollow lead vessel *c*, of a thickness of 2 mm., which is com-

[1]Phys. Zeit., March 15, and Elec. World and Eng., April 9, 1904.

pletely insulated from *b*. Through *b* passes in spiral form the platinum wire, *f*, which is connected to the electroscope, *d*. The second electroscope, *e*, is fixed to the lead cylinder. As soon as a good vacuum is reached, both electroscopes diverge, *d*, with positive electricity, *e*, with negative electricity. It is also possible to demonstrate the current which flows from the interior of the glass tube to the lead cylinder,

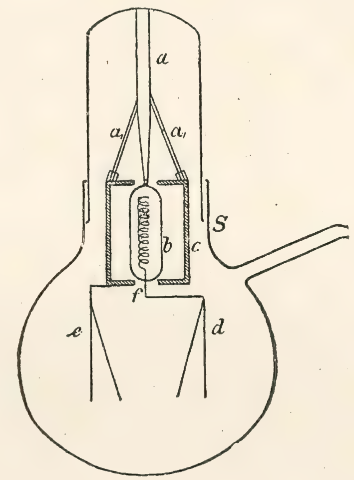

Fig. 44.—Paschen's Modification of Strutt's Apparatus.

if both are connected by a wire. This current was first measured by Wein. The divergence of *e* is always smaller than that of *d*, especially on account of imperfect absorption of the β radiation in lead of 2 mm. thickness. Within an hour the electroscopes converge and the charges of their conductors are neutralized, but the neutralization is not complete, both electroscopes showing afterwards a small positive charge.

Radium Radiation Complex.—The radiation of radioactive substances is a very complex one. There are three distinct types of rays distinguished. These are called by Rutherford the α, β, and γ rays.

In the first instance it was pointed out by Rutherford, that uranium possessed two distinct types of rays, α and β, the former easily absorbed even by gases, while the latter are very penetrating, and but little absorbed by gas.

(1) α Radiation.—The α rays constituting the greater part of the radiation are slightly penetrating. They are most active in ionization of gas, as has been observed under experimental conditions. They are readily absorbed and a thin screen of metal suffices to cut off the most of them.

The magnetic field acts very feebly upon these rays. At first they were regarded as non-deviable. In a strong magnetic field there is a slight deviation which is produced in the same manner as in the case of the cathode rays; but the direction of the deviation is reversed, and is the same as for the canalstrahlen of a Crookes tube. This shows their identity with the positively electrified particle or atoms. Their mass is enormous in comparison with the β group. Rutherford deflected as much as 45 per cent. of them in a strong electrical field. He estimates that the energy of α rays is a thousand times greater than that of the β rays, and they have very much less penetrating power. According to Rutherford all radio-active substances, including polonium, as well as excitable bodies and their emanations give out α rays. It has been observed by Rutherford[1] that the absorption of the α type of radiation emitted by uranium or any of its compounds was such that the intensity was reduced to one-half its value after passing through,

3 mm. of carbonic acid gas,
4.3 mm. of air,
7.5 mm. of coal gas,
16.3 mm. of hydrogen.

The penetrating power of the α radiation is intermediate between that of ordinary primary and secondary Roentgen

[1]Thomson: Conductivity of Electricity through Gases.

rays. The absorption of the α rays was shown by Rutherford to be proportional to the density of the gas.

(2) β Radiation.—The β rays are much longer, have greater penetrative power, are readily deflected by a magnet in the same manner, and in the same direction as the cathode rays, and they correspond in every particular to the cathode rays, which, as is now generally known, are identified with the free electrons projected into space and proceeding from tangible matter. In other words, these electrons, atoms of electricity, are not undulations of the ether, nor a form of energy, but substances possessing inertia, undoubtedly electric. The β radiation has a velocity approximating that of light, and the β rays are projected from the cathode at a speed approximating 70,000 miles per second. The flight of some of them is retarded by collisions. By them electrified bodies are discharged through ionization of the air; but their ionizing power is feeble compared with that of the α radiation. They have the power of impressing photographic plates, in fact they possess the properties of the cathode rays.

(3) γ Radiation.—The γ rays are the rays possessing the greatest penetrative effect, and they will excite or produce radio-activity at a distance of three feet or more. Rutherford's experiments show the relative penetration of the three classes of rays through aluminum sheets of varying thicknesses before there is a loss of half the intensity, which is formulated as follows:

α rays through a thickness of aluminum .0005 cm.
β rays through a thickness of aluminum .05 cm.
γ rays through a thickness of aluminum .8 cm.

They are unaffected by the magnetic field and are comparable to the Roentgen rays; that is, they are vibrations of the ether, produced by the sudden arrest of the cathode stream coming into contact with the solid matter just as in a Crookes tube.

The accompanying classic cut shows the relative direction and extent of the three radium radiations, α, β and γ.

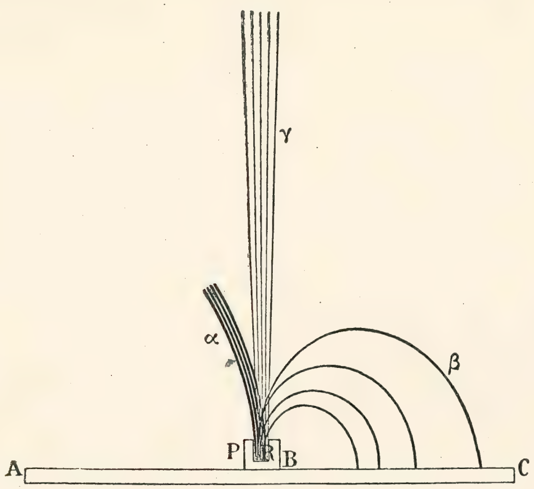

Fig. 45.—The β rays being negatively charged are bent strongly to the right. The γ rays ethereal pulses as are the X rays are not bent at all, and the α rays being positively charged but massive, are bent but very little to the left, less even than appears. It is estimated that if the diameter of the circle of bending formed by the β ray is a quarter of an inch that of the α ray circle of bending is eleven yards.

Let the radium, *R*, be placed at the bottom of a little cavity sunk in a block of lead *P*. A bundle of rays will escape from the cavity containing the radium. These are rectilinear and slightly expanding. If there be established in the region surrounding the hollow a uniform magnetic field the slightly intense gamma rays continue their rectilinear projection without trace of deviation. The Beta rays are deviated in the same manner as cathode rays, and as shown in the figure, describe some circular trajectories whose ray varies in extended limits. If the receptacle be placed upon a photographic plate A. C., the proportion B. C. of the plate upon which the energy of the β radiations falls receives an impression. Finally, the α rays form a very intense bundle, which is slightly deviated, and which is very rapidly absorbed by the air. These rays describe a trajectory, the curvature of whose ray is very large, the direction of the radiation being the reverse of that of the β rays. If the receptacle should be covered with a thin screen of aluminum, the α rays will be in a great part suppressed or arrested, the β rays less, while the γ rays do not seem to be noticeably absorbed. They go straight on as does the X ray.

Action of the Magnetic Field.—There are then two groups of rays very distinct the one from the other, of which one is easily deviated by the magnetic field, the β rays, while the other is apparently insensible to its action, the α rays and γ rays, known as the non-deviable rays. Despite this classification, which is classical, it will be recalled that Rutherford deflected slightly with a strong magnetic field the α rays or positive electrically charged atoms. The measurements of the magnetic field made electrically are confirmed by radiographic experiments. A very clear trace of the bundles separated by the action of the field is obtained upon a photographic plate placed parallel to the primitive bundle and normal to the field. Becquerel has shown that the impression constitutes a large diffuse band, a true continuous spectrum, and that the bundle of deviable rays emitted by the source is constituted of an infinity of radiations unequally deviable. The deviable rays β are charged with negative electricity, like the cathodal rays, and comport themselves as do the negatively charged corpuscles shot off from the cathode in a Crookes tube. It is a very feeble charge. Radium is the first example of a body spontaneously charged with electricity.

The velocity of the β rays of radium is greater than that of the cathode rays. Kaufmann[1] observed that this velocity closely approximated that of light, hence their great penetrating power.

Action of the Magnetic Field upon the α Rays.—Rutherford[2] has shown that in a magnetic field the α rays are

[1]Nachrichten d. k. Gesell. d. Wiss. zu Goettingen, 1901, Heft 2.
[2]Physik. Zeitschrift, 15 Jan., 1903.

slightly deviated and in the same fashion as the positively electrified particles or atoms as in the canalstrahlen of a Crookes tube. This accounts at least in a part for the law of absorption of radiation. If the charge of each projectile is the same as that of an atom of hydrogen in electrolysis, the conclusion is logical that the mass of this projectile is of the same order of magnitude as that of an atom of hydrogen in electrolysis. The projectiles which constitute the β rays are not only much smaller, 1/800 of an atom of hydrogen, but have a greater velocity than the α rays. The inference is drawn from these reasons, that they have a greater penetrating power which is the case.

The Influence of Air upon the β Rays.—The air, which the β rays traverse, produces an acute diffusion for the strongly deviable rays. This diffusion is, however, of much less importance than that which is due to equal thicknesses of solid matter traversed. For this reason the deviable β rays pass into the air at great distances.

Spinthariscope of Crookes.—It is the α rays which are active in the very beautiful experiment of Crookes.

A grain of radium is held at the extremity of a metallic thread before a screen of phosphorescent sulphid of zinc and from 0 mm. to .5 mm., for example, from the screen. When viewed by the means of a magnifying glass with the face of the screen turned toward the radiation, there is seen a very rain of luminous points. They are due to the α rays and the surface of the screen is literally bombarded by the positive atoms projected from the radium. The luminous points upon the phosphorescent surface are provoked by the shocks of isolated projectiles, and these scintillating phosphorescent patches are constantly changing their places due to the varying impingement of the positively electrified α rays. The aspect of the luminous points is the same as that of stars or of ultra-microscopic objects which do not produce upon the retina clear images, but spots of light. This is in full accord with the conception that each extremely small luminous point is produced by the shock of a single atom.

This Spinthariscopic phenomenon observed by Crookes, was studied by Becquerel[1] in order to determine to what kind of radium rays it is due, and what physical process the scintillations represent. For the screens he used the hexagonal zinc blend or diamond dust. In a strong magnetic field the rays producing the scintillations were not deflected. This confirms Crookes' supposition that the rays producing the sparks consist of positive electrons. As regards the nature of the scintillations, they are in general the more pronounced and vivid the smaller the crystals are which compose the screens. The sparks are most likely due to cleavages taking place in the crystal, and not to the mere impact of the positive ions. He finds that there exists here an analogy to the scintillations observed on breaking a piece of sugar.

Proportion of Deviable Rays β in the Radiation of Radium.—From their experiments made by the electrical method, the Curies, with a thin layer of the radiant substance found the proportion was as 29 to 100; with a layer five times as thick, they were as 45 to 100.

Penetrating Power of the Radiation of Radio-Active Bodies.—The radiations of radium have the power to penetrate opaque solids as does the X ray.

The rays emitted by radio-active bodies into the air are projected rectilinearly. This is shown by the clearness and the form of shadows furnished by the interposition of bodies opaque to the radiations between the source and the sensitive plate.

Distance to which Radium Rays are Propagated in the Air.—The gross mass of radium radiation is limited in the air to a distance of about 7 cm. from the source. After a certain distance, the intensity of the radiation varies inversely as the square of the distance from the condenser of the apparatus.

The following experiment of Madame Curie's is beautifully illustrative of the distance to which the different rays

[1]Comptes Rendus, October 27, 1903.

are propagated. The radium salt was placed in a glass bottle. The rays which go out from the bottle traverse 30 cm. of air and are received upon a series of glass plates of 1 mm. in thickness, 3 in number; the first plate transmits 49 for 100 of the radiation which it receives, the second transmits 84 for 100 that it received, the third transmits 85 for 100 that it received.

Ionizing Action of Radium Rays.—M. Curie has shown that the rays of radium and the rays of Roentgen act upon dielectric liquids as upon air, while communicating to them a certain electric conductibility. The rays of radium strongly ionize the air. By the action of radium there can easily be provoked the condensation of supersaturated vapor of water exactly as with cathode rays, Roentgen rays, and ultra-violet rays. Under the influence of radium radiations, the explosive distance between two metallic conductors for a given difference of potential is increased; in other words, the passage of the spark is facilitated by the action of the rays. This phenomenon is due to the action of the most penetrating rays. An enclosing envelop of lead 2 cm. thick about the radium enfeebles the action of the radium upon the spot but very little, while the radiation penetrating this thickness of lead is but a very small fraction of the total radiation.

Radium Radiations Render the Air Conductive.—By the action of the radio-active substances the air is made conductive in the vicinity of two metallic conductors of which one is grounded, i.e., bound to the earth, the other to a well-insulated electrometer. Under these conditions the electrometer takes a permanent deviation.

Fluorescent and Luminous Effects.—There are a great number of substances susceptible of becoming phosphorescent or fluorescent by the action of the Becquerel rays. Becquerel[1] studied this action upon the salts of uranium, the diamond, etc. M. and Madame Curie first discovered the phenomenon in making polonium act through a leaf of

[1]Curie.

aluminum upon a layer of platino-cyanid of barium. It has been shown by M. Bary[1] that the salts of the alkaline metals and alkaline earths which are all fluorescent under the luminous rays and the Roentgen rays, fluoresce equally under the action of radium rays. Paper, cotton and glass also become fluorescent in the vicinity of radium. The author has observed that the cotton which comes wrapped around the little tubes of radium glows luminously in the dark. Of the different kinds of glass, Thuringian glass is especially luminous. Metals do not appear to become luminous. This effect of radium can be observed at a distance of two metres (Curie). Phosphorescent sulphid of zinc becomes extremely luminous and preserves its luminosity for some time after exposure to the radium. This fluorescence produced by radium may be observed even when an absorbing screen is placed between the radium and the fluorescent screen. Madame Curie has observed the illumination of the platino-cyanid of barium through the human body. The action is much more intense, however, when the screen is placed directly against the radium. The luminosity of fluorescent substances produced by radium diminishes with time. At the same time the fluorescent substance undergoes a transformation. They reduce silver salts, peroxid of iron, and bichromate of potash in presence of organic substances; while glass, porcelain and white paper are colored by them, yellow platino-cyanid of barium is transformed into the brown variety, which is much less luminous. This transformed platino-cyanid of barium is partially regenerated by the action of light. Paper becomes altered and brittle, resembling finally a colander riddled with holes.

Becquerel in referring to the chemical action of radium rays, states that white phosphorus is transformed into red in twenty-four hours, mercuric chlorid in the presence of oxalic acid is reduced with a precipitation of calomel, and after long exposure the germinating power of seeds is

[1]Curie.

destroyed. To the same chemical action the coloration of glass, porcelain, paper, and certain crystals as well as the painful physiological effects are due. Glass is colored brown or violet and at the same time becomes less fluorescent. The coloring of glass by radium rays finds its counterpart in the coloring of X ray tubes. Those who have tubes steadily in use have noted that often they assume a violet tinge similar to the coloration produced by radium rays. It is also found by Becquerel that radium rays have the same power as the electric spark under exposure to heat, of restoring phosphorescent properties to a body deprived of them by overheating. The same is true of ultra-violet light. If this glass be heated it becomes decolorized and at the same time that the decolorization is produced, the glass emits light. After that, the glass recovers the property of fluorescence in the same degree as before the transformation. Sulphid of zinc which has been exposed to the action of radium for a sufficient time becomes exhausted little by little and loses the faculty of being phosphorescent, perhaps under the action of radium, perhaps under the action of light.

Diamonds exposed in the dark to radium rays fluoresce and scintillate in the most brilliant fashion. False stones are therefore easily detected.

The action of radium Roentgen rays and ultra-violet light on minerals and gems in relation to the production of fluorescence, a luminosity during exposure, and phosphorescence, a luminosity persisting after exposure to the source of radiations, has been most exhaustively studied by Dr. George F. Kunz and Professor Charles Baskerville.[1]

The most responsive of all the stones examined, however, were the diamonds containing that peculiar substance which gives them what is known as the blue-white color, fluorescent, like anthracene, and holding the luminosity for a long time, to which Kunz gave the name of Tiffanyite.

"Almost all diamonds, of various weights and from many

[1]Science, December 18, 1903.

localities and of different colors, fluoresce and phosphoresce more or less with radium, except the black or carbonado. The degree to which these phenomena are observed is no criterion of the grade of the gem, however, as stones with flaws often fluoresce with even greater brilliancy than the pure ones."

They concluded from their study of the collection, that one or the other of these forms of luminosity and activity may have a value to detect elements or compounds that have escaped notice, or are present in the minerals as impurities.

The same observers found that actinium also produced a brilliantly luminous effect upon willemite when incorporated with it, but did not possess the penetrating power of radium, as the actinium did not affect the willemite outside of the glass enclosing jar, although the glass was only $1\frac{1}{2}$ mm. thick.

Emission of Gas in Presence of the Salts of Radium.—A solution of bromid of radium discharges gases in a continuous manner, principally hydrogen and oxygen.[1] The composition of the mixture is near to that of water. There is a decomposition of water in presence of the salts of radium. It has been observed by one of the physicians in attendance upon the author's teaching clinic, that the ulcerated surface of an epithelioma, upon exposure to radium, "bubbled" as in electrolysis. The author has constantly noted that these surfaces after a radium treatment are moist as after an electrolysis.

The solid salts of radium, chlorid and bromid continuously emit gas. The pores of the solid salts are filled by these gases, and they are emitted in great abundance when the salt is dissolved. There is formed in the gaseous mixture hydrogen, oxygen, carbonic acid and helium; the spectrum of these gases present some unknown lines. Madame Curie describes the two following accidents occurring during M. Curie's experimental work, and due to the emission of gases:

[1]Giesel, Ber. 1903, p. 347.

A flask of thin glass filled almost full of solid bromid of radium, dry, exploded two months after its closure under the influence of a slight heating. The explosion was probably due to the pressure of the gas inside. In another experiment a flask containing chlorid of radium which had been prepared for a long time, communicated with a reservoir of considerable volume in which was maintained an almost perfect vacuum. The flask having been submitted to a rapid heating up to 300°C., the salt exploded. The flask was broken and the salt was projected to a distance; there must have been considerable pressure in the flask at the moment of the explosion. The apparatus had before been submitted to a trial of heat under the same conditions in the absence of the salt of radium and no accident was produced.

Evolution of Helium from Radium Bromids.—This phenomenon was first observed by Sir William Ramsay.[1] He observed that radium gave off a heavy gas, which, when collected in a glass vacuum tube and sealed off, was found by spectrum analysis to have changed in the course of some days from radium into helium. This phenomenon was also studied by Dewar and Curie,[2] who observed a change of radium into helium.

Emission of Heat by the Salts of Radium.—The phenomenon of the emission of heat is unique and unprecedented and a given specimen emits sufficient heat in an hour to melt its own weight in ice, while it maintains itself at a temperature of 1.5°C. above that of the surrounding medium. Nor is it affected by a wide range of temperature, the emission of heat going on without perceptible variation, whether on a summer day or at the temperature of liquid air. The excess of temperature depends also on the thermic isolation of the substance. Madame Curie and Laborde found that the amount of heat produced by one gramme of radium per hour is about 80 calories.

In liquid hydrogen, however, radium shows that it is not

[1]Ramsay and Soddy: Phys. Zeitschr., Sept. 15, 1903.
[2]Comptes Rendus, Jan. 2, 1904. London Elec., Feb. 12, 1904.

always unaffected by external temperature, for within a comparatively short distance of the absolute zero, the emission of heat, so far as present data can be relied upon, is augmented at the temperature of liquid hydrogen. This extraordinary phenomenon is increased in intensity at a point where all but the most powerful chemical affinities are in abeyance. This tremendous evolution of radiant energy goes on perpetually without combustion, without chemical change of any kind, without alteration of the molecular structure of the radium salt and without appreciable loss of weight. For one square inch of surface this loss of weight in ten million years is estimated at but one gramme. Apparently these facts are a violation of the law of conservation of energy. This result is not to be explained on the view that radium gains its heat from an external source, but upon the disintegration theory, whereby its own intra-atomic energy is converted into heat. On that theory the energy of radio-activity is derived from the internal energy of the atom liberated when it breaks up into smaller systems. As the atom breaks up the so-called α rays are pitched away with extreme violence, and they generate heat when they are stopped by any obstacle. In other words, radium converts its own intra-atomic energy into heat. When a salt of radium is first prepared it emits a relatively feeble quantity of heat. But this delivery of heat increases, tending toward a determinate value, which is not yet entirely attained at the end of a month. According to Rutherford and Barnes,[1] the heat emission of radium is probably due in part to the kinetic energy of the expelled α particles and in part to the energy released consequent upon the rearrangement of the components of the systems left behind after the expulsion of the α particles.

Production of Thermo-Luminescence.—Certain bodies, as fluorin, become luminous when they are heated; they are, therefore, thermo-luminescent. At the end of a certain time

[1]Phys. Rev., Feb., 1904.

their luminosity fades, but the faculty of becoming luminous anew by heat is restored to these bodies by the action of a spark, and also by the action of radium.

Photographic Power of Radium.—The rays which act photographically are the β and γ group. Unlike the Roentgen rays, there exists no difference between the transparency of the flesh and the bones. This is shown in the accompanying cuts of a mouse, a mouse in a trap, and a dead hand originally loaned the author by Mr. W. J. Hammer[1] for a monograph on radium.

To the courtesy of Mr. Hammer the author is indebted for their reproduction in this connection. These cuts are introduced as illustrative of the fact, that in radium-graphs, unlike radiographs taken with the X ray, there exists no difference between the transparency of the flesh and bones.

That of the mouse was made in 24 hours by laying it directly on the plate, and that of the mouse in a trap in 3 days. In the latter the wooden part of the trap is transparent as with the X ray. The dead human hand was exposed for 8 days. A slight trace of the bones can be seen. It is supposed to be the first picture of the human hand made with radium.

Radiographs may be taken with radium at considerable distances, and with sources of small dimensions. A much more beautiful radiograph may be made if the β rays be deflected by a magnetic field and the γ rays only utilized. There is produced a certain confusion and a certain blur by the β rays. A longer exposure is required when they are suppressed, but the results are better.[2] A *portemonnaie* requires a day with a radiant source consisting of a few centigrammes of radium salt enclosed in a flask of glass and placed in 1 m. from the sensitive plate upon which the ob-

[1]Margaret A. Cleaves: Radium, Its Physics, Physiological Action and Therapeutic Effects, American Electro-Therapeutic Association, Sept., 1903.
[2]Madame Curie.

Fig. 46.—Radium-graph of a Mouse made by Radium in Twenty-four Hours.

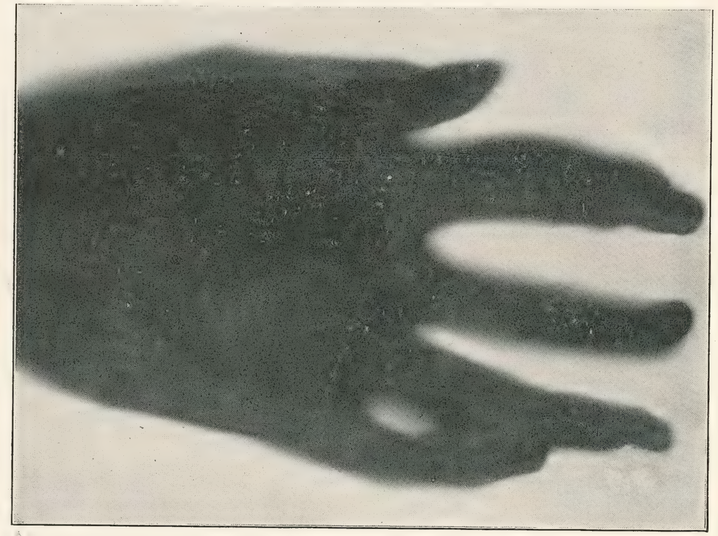

Fig. 47.—Radium-graph of Dead Human Hand.

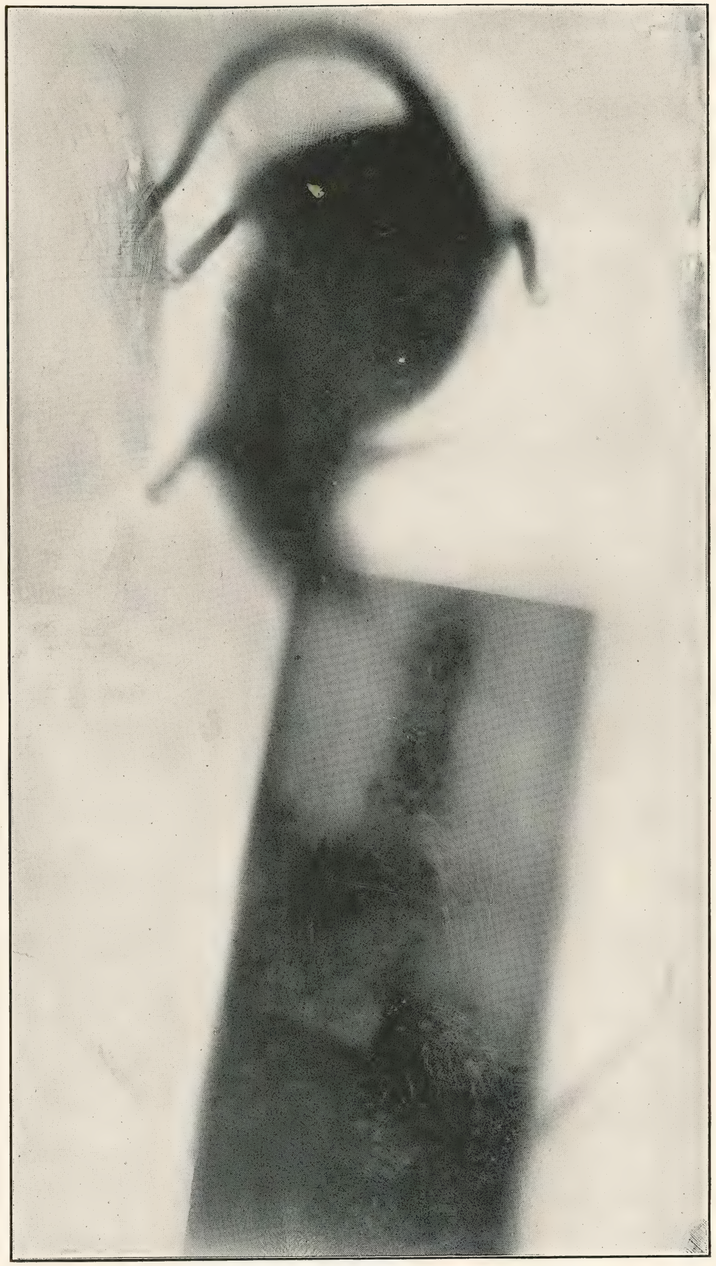

Fig. 48.—Radium-graph of a Mouse in a Trap.

ject is laid. The same result is obtained in an hour if the radium is placed at 20 cm. distant from the plate. A sensitive plate is immediately impressed in the immediate vicinity of the radiant source.

Induced Radio-Activity.—Substances which have been in contact with radium become radio-active and their radio-activity lasts for varying periods of time. Professor Curie states that it is impossible for him to go near his instruments to make any measurements for hours after being near radium, and those who work with it, find it extremely difficult to keep their tools, instruments and themselves free from the radio-activity imparted by the radium. Falling rain and snow are for a time quite powerfully radio-active and lightning rods and even the leaves of trees also become radio-active. It was found by McLennan that rain caught in a vessel and immediately evaporated to dryness, imparted a radio-activity to the vessel. Hammer found a piece of cardboard which had formed the box holding his radium, luminous in the dark after six days. This radio-activity was stimulated by burning magnesium wire before it.

M. and Madame Curie found that the radio-activity thus acquired is not due to a transference of radio-active particles which are deposited on the surface of the neutral substance. The induced radio-activity disappears when these naturally inactive substances are withdrawn from the influence of the radium. This induced radio-activity has been studied by the electric method, and the following facts observed: (1) The activity of a plate exposed to the action of radium increases with the time of exposure and approaches a certain limit following an asymptotic law. (2) The activity of a plate which has been activated by the action of radium, and which has been withdrawn from the action disappears in a few days. This induced activity tends toward zero in function of time, following an asymptotic law. (3) All conditions being equal, the radio-activity induced by the same radiferous product upon various plates is independent of the nature of the plate. Glass, paper, metals, are active with

the same intensity. (4) Radio-activity induced upon the same plate by various radiferous products has a limit value as much more elevated as the product is more active.

Irregular results are obtained when the "activation" is produced in free air. It has been observed by Madame Curie and Debierne that the phenomenon is perfectly regular when it takes place in a closed vessel.

Activitation in a Closed Receptacle.—If a little flask containing radium open at the top be placed in the centre of a closed receptacle, and then various metallic plates placed around it, the latter become radio-active at the end of the day. If the dimensions are equal, the activity is the same whatever their nature, whether of lead, aluminum, copper, glass, ebonite, wax, cardboard, or paraffin. The activity of the face of one of these plates is as much greater as the free space before this space is greater. If the experiment is repeated with the flask enclosed no induced radio-activity is obtained. Radio-activity may be transmitted by the air, gradually from the radiant source to the body to be acted upon. It can even be transmitted to a distance by very straight capillary tubes. The action is both more intense and more regular when an aqueous solution of the solid salt is used than with the salt itself. Liquids are capable of acquiring radio-activity, pure water, for example. When placed in a radio-active enclosure certain phosphorescent and fluorescent bodies become luminous, glass, paper, cotton, water and saline solutions, for example. The limit of induced radio-activity is independent of the nature and pressure of the gas present in the "activating" solution. It depends upon the quantity of radium enclosed in the state of solution and seems proportional to it.

Rôle of Gases in the Phenomena of Induced Radio-Activity.—Gases present in a radium enclosing receptacle, either salt or solution, become radio-active. This radio-activity persists even when the gas is aspired but finally disappears entirely. This radio-active energy enclosed in gases exists in a special form. Rutherford supposes that

certain radio-active bodies, radium, thorium and actinium, are constantly emitting a material gas which he calls emanation.

Disactivation.—By this is meant the loss of radio-activity. When a solid body which has been exposed for a sufficiently long time, and is then withdrawn into the free air it loses its radio-activity. This loss follows definite laws and has been determined mathematically. This law of disactivation is such that the intensity of the radiation falls one-half of its value in 28 minutes. Disactivation takes place much less rapidly in a closed vessel than in the free air, and by the mathematical formulæ it has been found that the intensity of the radiation under these conditions diminishes one-half in four days. For temperatures between 180° and 450° this law remains the same.

Rutherford[1] has shown that heating has an enormous effect on the issue of the emanation from radium. Experimentally it was shown that 19/20 of the ionization was due to the emanation when the emanation was present, and that three-fourths of the ionization was due to the emanation when the latter was blown out, and one-fourth to induced radio-activity.

The molecular weight of this emanation from radium has been found by Rutherford and Miss Brooks to be between 40 and 100. This emanation is not the vapor of radium, as M. and Madame Curie have shown that the atomic weight of that substance is 225.

Elster and Geitel[2] have demonstrated that a very feeble proportion of radio-active emanation analogous to that emitted by radio-active bodies exists in the atmospheric air.

Radium emanations are also found in the air extracted from certain mineral waters, while the air of the waters of the sea and rivers are scarcely exempt. The air from a tube forced into the ground is particularly charged with emanation. The waters of a number of mineral springs famous

[1]Quoted by Thomson.
[2]Physik. Zeitschr., Sept. 15, 1902.

as health resorts have been analyzed to ascertain to what degree they were radio-active. Among these may be mentioned those of Bath. Dewar[1] had found the element helium present in these waters, and Strutt[1] found that the deposits in the tanks and at three of the Bath springs contain radium in appreciable quantities, though not enough to pay for extraction. He thinks there can be little doubt but that the helium of Bath owes its origin to large quantities of radium at a great depth below the earth's surface. A little of this radium is carried up by the rush of hot water, and it is found in the deposit.

The deposit which Mr. Strutt examined is one of countless peculiar features of the Bath waters. It settles on walls and the bottoms of tanks and corrodes pipes, being like mud of a rich orange color. When dry it is orange-colored powder, but duller in hue and very fine in substance. Settling on stone or projections, it hardens and assumes the appearance of coral or fungus.

J. J. Thomson[2] found that the radio-active gas found in Cambridge tap water possessed properties similar to the emanation of radium. Professor Bumstead[3] of Yale found the radio-active gas in the ground and the surface water near New Haven to be identical with the emanation from radium. Many different springs have been exploited in the daily press as radio-active. It might be supposed that radium emanations were present in the gas of the waters of the river Jordan into which the Syrian Naaman dipped himself seven times as directed with the result of the healing of all his sores, his flesh becoming soft and smooth as a baby's. It is quite conceivable that a substance undergoing such constant change and disintegration as does an atom of radium may fling off from itself something of therapeutic value. Such substances in a nascent form would be more active and therefore the inefficiency of the waters of certain springs

[1]Elect. World and Eng., Editorial.
[2]Phil. Mag., Nov., 1903.
[3]N. Y. Sun, Feb. 1, 1904.

when removed from their source might be explained. Nor is it possible to imitate these springs artificially successfully.

Nature of the Emanations.—Rutherford[1] regards it as a material radio-active gas. From many points of view the radium emanation comports itself as an ordinary gas. Emanations from thorium and radium do not seem to be altered by various very energetic chemical agents, and for this reason they are likened by Rutherford and Soddy to some gas of the family of argon.

Induced Radio-activity Varies with Different Substances. —The laws formulated for induced radio-activity do not cover all substances. Celluloid, paraffin, caoutchouc, etc., are disactivated very slowly. more than the laws given permit. They have been known to retain their induced radio-activity from 15 to 20 days. There are again other bodies, such as plates of copper, aluminum and glass, which at first follow the law of disactivation; but when the activity has fallen to about 1/20000 of the initial value, it diminishes neither more nor less. It develops very slowly, sometimes even it continues to increase. The Curies have some such substances which have been radio-active for more than six months. In this connection it may be mentioned that McClennan and Burton[2] from their experiments regard metals generally as radio-active.

Radio-activity Induced upon Substances which Remain in Solution with Radium.—This was observed by the Curies in the work of chemical separation to isolate radium salts. All the substances in the mineral are found in a more or less induced radio-active state. The induced radio-active bodies disappear in proportion as the radiant bodies become concentrated. The induced radio-activity of laboratory apparatus has been referred to. The dust and air of the room also become radio-active. The air of the room is a conductor. Says Madame Curie, "In the laboratory where we work the

[1]Phil. Mag. 1902, p. 580, 1903, p. 457, quoted by Madame Curie.
[2]Phil. Mag. Sept., 1903, Abst. Electrical World and Engineer, Oct., 1903.

evil has arrived at an acute state and we can have no longer a well-insulated apparatus."

Variations of Activity of the Radio-Active Bodies. Effects of Solution.—Polonium diminishes in radio-activity as time goes on. In a specimen examined, in 6 months 67/100 of its activity is lost. Contrary to this, the radiferous salts possess a permanent radio-activity which does not present appreciable loss at the end of some years. A salt of radium prepared in the solid state does not at first show a constant activity. Its activity goes on increasing and attains a value limit at the end of about a month. The contrary is the fact for a solution. First prepared it is very active, but left in the air it becomes rapidly disactivated, and finally attains an activity limit which may be considerably more feeble than the initial value. These variations were first observed by M. Giesel.[1]

Time Taken for Activity to Fall to Half its Value.—The duration of the activity of a radio-active substance is the property by which it is most easily recognized. Therefore the following table showing the time taken to fall half its value in those cases in which it has been determined.[2]

Thorium emanation, one minute.

Induced activity due to thorium, 11 hours.

Radium emanation, 4 days.

Induced activity due to radium, 28 minutes.

Actinium emanation, a few seconds.

Induced activity due to actinium, rather less than 28 minutes.

Radio-active gas from water, 4 days.

Induced radio-activity due to this gas about 40 minutes.

Induced radio-activity on a negatively electrified wire in the open air, about 40 minutes.

If radio-active waters artificially produced are to have any value for therapeutic purposes, they must, according to the above, be used when first prepared.

[1]Wied. Ann. t. LXIX., p. 91, quoted by Curie.
[2]Thomson: Conduction of Electricity through Gases.

Theory of Radio-Activity.—Curie and Debierne[1] advance the theory that each atom of radium functions as a constant and a continuous source of energy, without being precise about the source of this energy. The radio-active energy which accumulates in radium tends to dissipate itself in two different fashions: (1) By radiation (rays charged and not charged with electricity; (2) by conduction, that is to say, by transmission gradually to neighboring bodies, by the intermediary of gases and liquids (emission of emanation and transformation into induced radio-activity).

Nature and Cause of the Phenomena of Radio-Activity.—The rays given off by radium are analogous with the group of rays which exist in Crookes tubes, cathode rays, Roentgen rays and canal rays. These are also the same group of rays found in the secondary radiation produced by Roentgen rays[2] in the radiations of the bodies which have acquired the induced radio-activity. While the nature of the phenomenon is actually better known, the cause of spontaneous radio-activity remains mysterious. Says Madame Curie, "And this phenomenon is still for us an enigma and a subject of profound astonishment."

Is the energy created in the radio-active bodies themselves or is it borrowed by these bodies from exterior sources? Experiments, says Madame Curie, do not confirm any of the numerous hypotheses arising from these two ways of looking at the subject.

The hypothesis of atomic transformation of radium is supported by the most recent researches. This was believed by the Curies and also by Rutherford[3] from the first. The recent experiments of the latter tend to prove that the emanation is an unstable gas which is destroyed in giving place to a production of helium. The continuous output of heat furnished by radium cannot be explained by any ordinary

[1]Curie et Debierne, Comptes Rendus, 29 Juillet, 1901.
[2]Sagnac, Thèse de Doctorat.—Curie and Sagnac, C. R. Avril, 1900.
[3]Rutherford and Soddy, Phil. Mag. May, 1903.

chemical action, but might have its origin in the transformation of the atom. The new radio-active bodies, says Madame Curie, are always found in the minerals of uranium and they have vainly sought for them in the barium of commerce. The presence of radium, therefore, seems allied to that of uranium. These uranium minerals contain besides argon and helium, which cannot be regarded as due to chance. The simultaneous presence of these bodies suggests that the presence of one may be necessary for the formation of the other. Or again, instead of the atom of radium being transformed, perhaps this atom is stable but acts upon the medium which surrounds it, in a manner to give place to atomic transformations.

This hypothesis leads to the admission of the possibiity of transformation of the elements; but radium itself would then be no more than an element on the road to destruction.

The Action of Radium on Bacteria.—Danysz[1] found that the salts of radium dissolved in distilled water emit certain emanations which prevent the development of Anthrax bacilli. E. Aschinass and W. Caspari[2] found that the germs of the micrococcus prodigiosus when exposed to a radium preparation were effectively killed in about three hours by the action of the ray.

Caspari expressed himself as follows to the Society of Internal Medicine of Berlin, July 6, 1903: "The rays of Becquerel have a bactericidal action. Experiments have been made upon the bacillus of tuberculosis in introducing them into the anterior chamber of the eye of the 'cobaye,' and also injecting some radio-active substance. There was no infection. Diphtheritic bacilli provoke, on injection into the muscles of the 'cobaye,' œdema, inflammation, then necrosis of tissue; if this injection is followed immediately by an injection of insoluble radio-active substances, there is produced no necrosis and there is favorable action upon the

[1]Rev. Internat. d'Elec.
[2]Ann. der Physik, t. VI., 1901, p. 570.

pathological process. The animals which have received the radio-active injection discharge the electroscope, and their blood becomes radio-active. Theoretically, it is necessary also to admit the possibility of an action upon carcinoma, for radium causes its disintegration." Caspari used the radio-active salt of barium.

Hoffman[1] sought to confirm the results obtained by Aschinass and Caspari. Five milligrams of pure bromid of radium was placed for three hours in the incubator at 23°C., at 3 millimetres and a half distance from the culture, then it was withdrawn, and 23 hours after, microscopically, the parts which had been submitted to the influence of radium showed no colony of bacteria, and all the spores were absolutely destroyed.

Pfeiffer and Friedberger[2] experimented with 25 milligrams of bromid of radium placed in a capsule of nilconite, surrounded with a plate of mica, the whole protected by an envelope of copper provided with a central window. The rays engendered by this small quantity were capable of traversing a plate of bronze 5-6 millimetres thick. The first experiments, made at a distance of 6-10 cm. upon the cholera and typhoid bacilli, were negative. The cultures were finally placed at a distance of 1 cm. from the radium. If, first, the gelatin is exposed before culture to the action of the rays, the gelatin undergoes no modification capable of preventing the development of the cultures when later inoculation is practiced. They found that the spores of anthrax succumb at the end of three days of exposure.

Mr. Henry Crookes, May 15, 1903, at a Conversazione of the Royal Society, showed plate cultures of several kinds of bacteria which had been exposed to a radium emanation through a mica screen. The results proved the "bactericidal effects of electrons from radium."[3] It was found in every

[1]Hygienische Rundschau, XIII., 18; Anal. in Revue de Therapeut., 15 Octobre, 1903.
[2]Rev. Internat. d'Elec., Jan., 1904; from Berlin klin. Wochenschrift, 13 Juillet, 1903.
[3]Medical Electrology and Radiology, Editorial, Jan., 1904.

case that the organisms were killed in those places where they had been exposed to the action of over 10 milligrams of radium bromid. On incubation a bare space free from bacterial growth was left on the plate opposite the point where the radium had been placed. The organisms so exposed were bacilli liquefaciens, bacilli coli communis, and bacilli prodigiosus.

The Action of Radium on Vegetable and Animal Organisms.—M. Giesel has remarked the action of radium upon the leaves of plants. The leaves submitted to its action grew yellow and fell.

Professor A. Danilewsky[1] makes the observation that he has seen the movements of young infusoria stop under the influence of radium, while those of the adult infusoria were not modified under the action of this substance.

M. Danysz showed the destructiveness of radium to the life of mice, rabbits, guinea pigs, chickens in embryo and vegetables.

His experiments further proved the vivifying influence of radium when used in a milder form. It also was used to the point of arresting transformation of the larvæ and some species grew to a very much greater size. Angle-worms that were exposed to radium rays crawled away from their direct influence and lived, while others that were confined directly to the stronger influence of the rays were killed. Caterpillars became paralyzed and died when exposed to the action of radium.

Experiments were made by M. Böhn at the Biological Laboratory in Paris for the purpose of determining what modification radium rays will have on lower forms of life. Mr. Böhn created monsters of the tadpole and there was a change in their breathing apparatus. He had used radium for the purpose of altering fecundated species. He used radium to create life in the unfecundated eggs of the sea-

[1]Conference méd. de la clinique des maladies mentales et nerveuses à Saint-Petersbourg, le 18 Sept., 1903 in Roussky Vratch, 1903, No. 47.

urchin and it is claimed that they were advanced through several stages of development.

Radiumized meal worms die, but those which live on show such retardation, that while those of the control test pass through the cycle of life, becoming beetles which lay eggs, which grow to worms, during the allotted three months, and repeat this cycle three or four generations, the radium worms still remain meal worms. They have been said to be veritable Methuselahs.

Dr. London, of St. Petersburg, found that when a box containing radium bromid was placed in a cage in which mice were kept, the animals became paralyzed and comatose, and died in five days.

Destructive Action of Radium.—Danysz is quoted as having said: "I have no doubt that a kilogram of radium would be sufficient to destroy the population of Paris, granting that they came within its influence. Men and women would be killed just as these mice are killed. They would feel nothing during their exposure to the radium nor realize that they were in any danger. Weeks would pass after their exposure before anything would happen. Then gradually the skin would peel off and their bodies would become one great sore. Then they would die from paralysis and congestion of the spinal cord."

Action of Radium on Chlorophyll Containing Organisms. —The most recent published experiments on the effects of radium on the lower organisms are those of E. G. Wilcox.[1] Wilcox has experimented with a number of chlorophyll containing organisms, and has found that those, and those only, are sensitive to the action of the rays. To the β rays there was a definite radiotaxis. In the course of a few hours all the animals moved out of the path of the pencil of β rays. Non-containing chlorophyll organisms did not seem to exhibit this power, although they speedily disintegrated under the influence of the rays. Of especial interest were the ex-

[1]Journal Physiology, Cambridge, 30, p. 449. Also Medical Electrology and Radiology, August, 1904.

periments upon two common forms of hydra. Hydra viridis showed great power of resistance to the rays when prevented from moving out of their sphere of influence, although whenever possible the animal would move out of the path of rays as quickly as possible. Hydra fusca, on the other hand, which does not contain any chlorophyll, did not move out of the rays, but was quickly killed by them. The animals were bisected, a procedure in these animals which is followed, by no great interference with their normal course of existence, in order to determine which part of the animal was susceptible to the ray. The oral disc was found to be the most susceptible, only this half moving out of the path of the rays. Chlorophyll is a fluorescent substance, and there is undoubtedly a relation between its fluorescent properties and its protective and sensitizing powers. This point is of especial interest in that the chlorophyll in those animals is probably only contained in the cells of commensal algæ, and exhibits in a very marked way the mutual relationship existing between the alga and its host. The opalina ranarum, a colorless organism, did not exhibit any sensitiveness to the rays. Thus far the β rays only have been experimented with, a disc of lead being interposed between the organism and the radium. Exposure to the unprotected radium was more marked, hydra viridis even being affected and disintegrated. The effect of chlorophyll was seen in this case, the green variety being more resistant than the brown.

Physiological Effects—The Action of Radium upon the Skin.—Becquerel, Giesel, the Curies, and others have given important evidence as to the serious physiological effects of radium. Becquerel from carrying a specimen in his pocket for six hours received a serious burn on his abdomen.[1] Hammer[1] felt the effects for weeks from carrying a wooden box containing eight tiny tubes under his arm for several hours.

M. J. Danysz, in a report to the Academy of Sciences, states that the application of a tube containing a salt of

[1]"Radium Selenium and Ultra-violet Light," Hammer W. J.

radium to the skin produces an ulcer in from 8 to 20 days. A few moments' application is followed by a congestion of the human skin. When applied to the skin of a rabbit destruction of the epidermis follows, but when applied under the skin there is only a feeble reaction on the epidermis. It seems to penetrate the muscles with difficulty. Danysz also found that the intestines and the serous surfaces, when the tubes containing the radium were introduced into the cavity of the guinea-pigs and allowed to remain for several hours, were but little affected and no lesions produced comparable to those of the skin.

The action of radium rays upon the epidermis was first observed by M. Walkhoff,[1] and confirmed by M. Giesel,[2] then by MM. Becquerel and Curie.[3]

Madame Curie gives the following interesting description of the action of radium upon the skin: If upon the skin be placed a small capsule of celluloid or caoutchouc enclosing a very active salt of radium, and left there some time, a redness is produced upon the skin, perhaps immediately, perhaps after some time, which is just so much the longer as the action has been more feeble and less prolonged. This red mark appears at the place which had been exposed to the action; the local alteration of the skin manifests itself and develops like a burn. In certain cases it forms a blister. If the exposure has been prolonged, there is produced an ulceration very slow to cure. In one experiment, M. Curie caused to act upon his arm a relatively feeble radiant product for ten hours. The redness appeared immediately, and formed later a wound which took four months to heal. The epidermis was destroyed locally, and was regenerated in the healthy state, only slowly and painfully with formation of a very marked cicatrix. A burn of radium with exposure of a half hour appeared at the end of 15 days, formed an ampulla and healed in 15 days. Another burn, made with

[1]Phot. Rundschau, Oct., 1900.
[2]Berichte d. deut. chem. Gesell. t. XXIII.
[3]Comptes Rend. t. CXXXII., p. 1289.

an exposure of 8 minutes, only occasioned a red spot which appeared at the end of two months and was insignificant in effect.

The action of radium upon the skin can be produced through metals, but it is feeble. To guarantee one's self from action, it is necessary to avoid carrying radium a long time upon the person unless wrapped in a sheet of lead.

M. Poussep[1] reported the formation of an ulcer upon his own skin exposed for six hours to the action of 1.5 milligrams of radium enclosed in a box. After the removal of the radium, Poussep felt nothing for 6 days. At the place exposed to the radium there then appeared a white spot, encircled with rose, of a size 3.5 cc. in diameter, and which at the end of 11 days was transformed into an atonic ulcer rebellious to all treatment. The ulcer showed a tendency to cicatrization under the influence of white light after 5½ months. This cutaneous lesion, provoked by radium, did not appear to Poussep to be a simple burn, but rather a necrotic process.

The Action of Radium upon the Eye.—M. Geisel[2] discovered the action of the rays of radium upon the eye. The ocular phenomenon or sensation of light when a tube is held close to the eye or near the temple is one of the most familiar of the phenomena of this agent. The phenomenon has been studied by MM. Himstedt and Nagel.[3] These physicists have shown that all the media of the eye become fluorescent by the action of radium, and that this explains the sensation of light perceived. The blind, where the retina is intact, are sensitive to the action of radium, while those whose retina is diseased do not have the luminous sensation due to the rays.

The action of the rays of Becquerel upon the eye has been studied by Hoffman,[4] who submitted every day for 6 minutes the cornea of a rabbit to the action of radium, from

[1]Arch. d'Elec. Med., Feb. 25, 1904.
[2]Quoted by Madame Curie.
[3]Ann. der Physik. t. IV., 1901.
[4]Revue Internationale d'Électrothérapie, Jan., 1904.

July 4 to August 2, without observing the least lesion of the cornea or of the crystalline lens. The retina alone reddened later. The pupillary reaction remained always normal.

The Action of Radium upon the Nervous System.—Recently, M. Danysz[1] has shown that the rays of radium act energetically upon the spinal cord and brain. After an action of an hour, paralyses are produced in animals submitted to the experiments, and they generally die at the end of a few days. Its action upon the nerve centres was noticed in all animals subjected to experiment, but it was comparatively feeble in those whose osseous tissue protected the nerve centres. Application of the tubes containing the salt to the cranium caused paresis, ataxia, and convulsions, followed later by death.

Hammer experimented with an electric torpedo in the Aquarium at Naples by placing six tubes of radium on the back of the fish, which is shaped like a flounder, leaving them there for twenty minutes.

Prior to doing this both he and the members of his party had received powerful shocks from the torpedo's batteries. Upon removing the radium he tried for fifteen minutes to get a shock from the fish in the same manner as before, but without success. He admits that the fish "might have been out of shocks" but the question which naturally arose, was whether a partial paralysis had not been induced by the action of the radium rays. This seems more than plausible in view of the fact that Professor Curie found that a few milligrams of radium introduced beneath the skin of a mouse over the vertebral column produced death by paralysis in three hours; and tubes of radium placed in contact with the back of the neck of guinea-pigs have paralyzed these animals in a few hours, according to the length of the exposure.

The Action of Radium upon the Excitability of the Cerebral Cortex.—M. Jaukovsky[2] has proved that a box contain-

[1]Comptes Rend. 16 Fevr., 1903.
[2]Conf. med. de la Clin. des Malad. mentales et nerveuses à St. Petersbourg, 18 Sept. 1903, in Roussky Vratch, 1903, No. 47.

ing 10 to 15 milligrams of radium applied upon the surface of the brain augments at first and diminishes later the excitability of the cerebral cortex. The degree and duration of the augmentation of cortico-cerebral excitability is in proportion to the quantity of the metal supplied and to the intensity of its radio-active properties. After a period more or less long of increased excitability, this diminishes gradually and falls sometimes below the normal.

Therapeutic Uses of Radium. Lupus Vulgaris.—M. Danlos,[1] at Hospital St. Louis, reports several cases treated by radium.

Case I.—Lupus of the face exposed to the action of a salt of radium, at two points, which had a radio-activity of 19,000, for from 24 to 36 hours. The result was disappearance of the disease with the formation of a smooth, white cicatrix, blending into the surrounding normal tissue.

Case II.—Lupus of face, ears, neck and hands of ten years' duration. Three different areas exposed to 5,200 radium for 24, 48 and 54 hours respectively; each of these three regions was cured while the unexposed areas remained as they were.

Case III.—Lupus of the hands of 20 years' duration. One portion treated with Finsen light, 110 sittings; improving slowly. Another portion treated with 5,200 radium, five applications of 24, 39, 39, 40 and 63 hours' duration shows marked improvement, in decided contrast to that treated by the Finsen light and in favor of the radium.

Case IV.—Lupus nodules near the eye, treated with 2,500 radium; cured.

Case V.—Extensive lupus of the hands treated with 19,000 radium, at five different areas for single exposures of 24, 36, 72, 96 and 120 hours respectively. The areas in the first four places were cured. The man then ran away from the hospital and turned up six months later at another place,

[1]Danlos; 1901 and 1902: Several articles on the treatment of lupus by radium. Ann. de dermat. et syph., Paris, June 1901, p. 367; November, 1901, p. 986; and July, 1902, p. 723.

to be treated by MM. Hallopeau and Gadaud, for an ulcer on the back of his hand, caused by the radium. M. Danlos saw the case again, and recognized the ulcer as being at the location of the radium application and of the shape of the radium vial. He advised a shorter exposure in future cases. This burn was inflicted in the first series of cases in which radium had ever been used therapeutically, and when there was no standard of dosage.

Dr. Blandamour[1] has also used radium in lupus. His best results followed the use of salts with a radio-activity of 5,200 and 19,000 respectively.

The exposures were made from 24 to 40 hours and were followed by profound erythema with maceration of the tissues exposed and even ulceration. The recovery was perfect and the cosmetic effect good, the resulting scar being white, smooth, and soft. By modifying the power of the radium and shortening the exposure he expressed the hope that the desired effect might be obtained without ulceration.

J. A. S. Mackenzie Davidson[2] in charge of the Roentgen ray Service at the Royal London Ophthalmic Hospital, and at the Charing Cross Hospital, reports several cases where radium (bromid of) was used.

No. 1.—Rodent Ulcer. Had resisted treatment by X rays and Finsen light. Seven applications, extending over six weeks. Examination, four months after, showed scarcely a trace of the disease.

No. 2.—Tuberculosis verrucosa cutis. Seven applications extending over 6 weeks. Disappearance of lesion.

No. 3.—Rodent ulcer of nose. Eight applications, extending over two months. Case cured.

No. 4.—Epithelioma of right side of face. Three operations. Treated by X rays. No arrest. Six applications, extending 6 weeks, marked improvement in course of which two erysipeliform attacks took place, after which treatment

[1]Sem. Medicale Ians, 1903.
[2]Brit. Med. Jour. 23 Jan., 1904.

resumed. Improvement was slow but regular. Salivation diminished, the tongue became normal, the appetite reappeared, cicatrization progressed and it seems perfectly legitimate to hope for complete cicatrization.

No. 5.—Nævus, degenerated with characters of malignancy, which disappeared after a few applications of a single tube of radium.

Epithelioma of the lower part of the right cheek. Treatment consisted of applications for 15 minutes of 5 milligrammes of bromid of radium enclosed in a tube of glass. After the first application the patient experienced relief from pain. After 5 séances, no more hemorrhages took place; pain and sensibility had disappeared. After 7 séances granulations of good quality appeared. The ulceration was deep and was long in cicatrizing; it left a depressed cicatrix.[1]

Mackintyre[2] has reported two cases of lupus treated by radium.

Lupus of the nose and hand; the area on the hand was a half inch in diameter; treated by radium (strength not given, probably a German preparation), exposed daily 20 to 30 minutes for three weeks and completely healed.

Lupus of the nostril and nose, one inch in diameter; treated similarly daily for 4 weeks and cured. This case had been under treatment in the previous year by the Finsen light, and had disappeared only to recur in two months.

Holzknecht adds another case of lupus.

Lupus tumidus that became flatter under both Finsen light and radium. For some reason the treatment was continued under the Finsen light.

Dr. Robert Abbe[3] adds still another case of lupus of the face, treated by a single exposure of an hour and a half to

[1]Gerald Sichel, Chief of Actino-therapeutic service, Guy's Hosp. (Brit. Med. Jour. Jan. 23, 1904).
[2]Mackintyre, John; July 25, 1903, and June 6, 1903: On the therapeutic effects of the salts of radium. Brit. M. J., Lond., p. 199.
[3]Abbe, Robert; November 10, 1903: The Status of Radium. Address before the Mercer County District Medical Society, at Trenton, N. J. (Not published.)

300,000 radium, with complete disappearance of the lesion when the patient was next seen one month later.

In addition to these lupus cases, several other skin diseases have been reported as treated by radium.

Verruca Vulgaris.—Abbe[1] reports five cases of the ordinary wart cured by means of radium. The results were equally satisfactory no matter how long standing the case. The radium, 2 grains of 300,000 radio-activity, was placed in contact with the wart for one hour from one to four times. In from 3 to 4 days a pink zone appears about the base of the wart and it begins to flatten. Usually it disappears inside of 10 days, leaving a smooth skin.

Radium in Blindness.—Javal and Curie[2] have made numerous studies with a very active radium salt, placing it into a covered glass vessel, and this into a dense pasteboard box through which no ordinary light could pass. Two absolutely blind men, one as the result of optic nerve atrophy, the other through glaucoma, did not perceive the presence of the light at all. A third individual, afflicted with prolapse of the retina, retained light perception in a small portion of his visual field. When exposed to the radium rays he announced at once the appearance of a light and precisely in that part of his visual field which corresponded to the inviolate portions of his retina. A fourth individual, blinded by ophthalmia neonatorum, had thick corneal scars, form perception was completely lost, color perception was present to a slight degree. Exposed to the radium rays he at once noticed a lighting up of his visual field, even after the eye was covered with both hands; were it possible to make his cornea transparent he could be given perfectly satisfactory vision. In a fifth case the eye had become glaucomatous after an iridectomy, and all form perception was lost, light perception was retained; later the lens became cataractous, and light perception also failed. A consultant blaming the light blindness on the cataract, wanted to operate. Knowing that the sensitive

[1]N. Y. Med. Record, Aug. 27, 1904.
[2]American Medicine, April 25, 1903.

retina would have perceived the approach of the radium light, we could inform him that the removal of the cataract would not be of the least service in this case.

London[1] has found by research that a box enclosing 0.3 of a gram of bromid of radium placed in proximity to the eye or even near the cranial vault provokes in man, whose eye has previously been kept in darkness, a strong luminous sensation. The rays of radium produce in the retina fluorescent properties; they are retained by the various media of the ocular globe without being reflected, and without the least refraction. They do not augment the acuteness of vision, but they excite very probably the visual centre.

Experiments made upon a rabbit showed that a prolonged action of radium upon the eye provokes in the latter inflammatory phenomena which only appear four weeks after the application of the radio-active rays. London has utilized the fluorescent properties of radium to teach certain blind subjects, suffering from atrophy of the optic nerve, but having preserved a part of the retina, to distinguish clearly upon the fluorescent screen letters, figures, and even to decipher entire words.

Subsequent to London's experiments, the action of radium on the eye was studied by Professor Greef[2] at La Charite, Berlin. His conclusion "that nothing in aid of the blind is to be expected from radium" receives the author's unqualified endorsement.

Radio-Active Substances in Neuralgia.—Foveau de Courmelles,[3] on the strength of experiments on mice performed by M. Danysz, of the Pasteur Institute, and the paralytic symptoms produced, regarded the resulting sedation as due to paralysis of the sensory nerves of the region treated, a paralysis which may by repeated subjection to the rays be carried to the point of deadening of the nerve fibers

[1]Archives des Sciences Biologiques de St. Petersbourg, t. X. No. 2, 1903.
[2]Deutsche Med. Wochenschrift.
[3]Progrès Médical, May 28, 1904.

equivalent to the effects of stretching or section of the nerve, with a sort of elective action on the morbid tissues. Pain, whether that of facial neuralgia or that of cancer, may be treated with success by means of local applications of radium chlorid, sometimes as frequently as three or four times a day, each application lasting for a quarter of an hour. Courmelles has found it simpler and free from the risk of dermatitis to apply plasters of oxid or nitrate of thorium. M. de Courmelles regards thorium as a "poor relation" of radium, possessed of no phosphorescence and of only two or three times the radio-activity of uranium. It may be left in position without danger, and the cure of very obstinate facial neuralgia obtained. A plaster of oxid of thorium is made in the shape of a sort of varnish, or the powder may be wrapped in tinfoil and applied to the seat of pain. If this is reinforced by the use of radium the result is reached more speedily. The action of the radium is concentrated by the tinfoil wrapper of the thorium, and the latter contributes its own power.

He refers to three cases of the successful employment of this treatment of facial neuralgia of several years' duration, in two of which the nerve had in vain been stretched and then divided. The simultaneous use of radium and thorium effected a cure in from three to eight days. Besides being free from danger, thorium has the advantage of being cheap. In his experience applications of acid nitrate of thorium, together with those of the high frequency current, have given excellent results in cases of lupus erythematosus.

Courmelles' experience is in accord with the action of radiant energy in painful nerve affections.

Exner[1] reports nine cases of cancer in which radium has effected very considerable lessening of the swelling and in two of these cases the swelling has not reappeared, although five months have elapsed since the treatment.

He believes that radium rays irritate the cells of the strata

[1]London Elec., Nov. 6, 1903.

of the skin less vehemently than they irritate the cells of cancer and sarcoma. The latter are brought to necrosis before the other tissues suffer severely from the effects.

Plimmer[1] regards it as probable that "the emanations from radium can only act upon young and rapidly growing cells, and that older cells, especially if surrounded by fibrous tissue, are less and less easily affected, and if there be an excess of fibrous tissue the cells are not at all affected."

Abbe[2] reports two cases of intractable epithelial ulcers of the upper part of the helix of the ear cured by means of radium. In the one case the ulcer was one inch long by half an inch wide. In this case Abbe tested the comparative action of the X ray and radium. To this end during the half hour's treatment with radium the half of the diseased area was covered by a lead plate, and the reverse during the two minutes X ray treatment. Applications were made on alternate days, rapid healing taking place under both methods. The hard edges flattened, the ulcer filled up with pink granulations, and newly cicatrizing skin appeared at both edges. By the sixth treatment the radium was ahead in its efforts. After two more applications the X ray had caught up and gone ahead. The recovery was complete, and at time of report the patient remained well. The second detailed case after six applications, each an hour in duration, recovered. In both instances a French radium, 2 grains of 300,000 radio-activity, was used.

Of far greater interest is a case of giant cell sarcoma of lower jaw bone of two months standing. The growth replaced the substance of the bone except its lower border, from the middle line toward the left for an inch and a half. The vertical measurement was one inch, and it was also one inch thick. Two incisor teeth and the canine were very loosely embedded. On the inner aspect an ulcerating surface rose half way up on the teeth. The submaxillary lymphatics were felt in the neck. The case was a strictly

[1]London Lancet, April 16, 1904.
[2]N. Y. Med. Record, Aug. 27, 1904.

surgical one, and would have required a mutilating operation. The radium was applied to the soft mass growing inward on alternate days for one hour each. After four applications there was a marked change, the purple exuberant ulceration grew pink and small, the internal tumor mass shrinking simultaneously. After eight exposures the entire interior portion had flattened and become hard. Then the external area was exposed to the action of radium, and later because of the gain he had made, Abbe wisely decided to carry the sealed glass tube of radium into the tumor mass, despite the observed fact that radium tubes when sterilized and embedded either in muscle, cellular planes or peritoneum of an animal tends to become encapsulated and inert. This has been shown by repeated experimenters in France and Germany, and also by Abbe in the Laboratory of St. Luke's Hospital.

In making the preliminary incision, the knife sank into the mass by its own weight, and when withdrawn it was followed by a free flow of blood. The radium tube was thrust into the incision and left buried within the tumor for three hours. Upon removal a piece of borated gauze was laid over the spot for ten minutes. The treatment was repeated three times weekly for 15 times. Twice a long interval was allowed between exposures, because of inflammatory reaction. Subsequent examinations were made at new points, and upon making them a gritty feeling of ossification beginning in some places, and less hemorrhage were noted. The loose teeth became firmer and stood straighter. After eight weeks of treatment it was discontinued. Four months later there was retrograde shrinking of all the peripheral remnant of the original growth. The walls retracted to nearly a natural line and ossific changes have established themselves. The photographs of casts taken before and after show the very marked change which had taken place, but the giant cell element was still present, as demonstrated by section.

The well-known untoward action of radium upon germinating seeds and the growth of plants, as shown by many

experimenters, and also by Abbe, led the latter to make a microscopic study of the action of radium on malignant cells. In a case of mammary cancer, one week before the operation, the radium tube was placed for 12 hours upon the sound skin within the field of operation. On each of six days a different place was chosen, once over a secondary growth, and once it was thrust into the substance of the tumor where it was left for 24 hours. After amputation the entire series was submitted to careful pathological study. Complete superficial necrosis took place on healthy skin with evidences of deeper inflammation shown in leucocyte infiltration into the cellular tissue, and about all the vessels and nerves, with some thrombosis of the small vessels. There was a marked change in the superficial cancer area, showing dissolution and retrograde change in nests of cells near the radium, but less at a distance. Sections were made at right angles to the line of the tube where it was thrust into the tumor. A marked sphere of influence was uniformly shown for a quarter of an inch on all sides. Outside that limit the nests of carcinoma were unchanged, but within it there remained none but degenerated and disappearing cells. What would have been the effect had the pathological change gone on cannot be said in this instance, as the operation ended the retrograde changes which had been established. The giant cell sarcoma, which shrank to one-quarter the former size under radium, showed structure of malignancy still, but with fiber structure predominating. Microphotographs, casts, and models of these as well as other causes treated by Abbe form a part of the radium exhibit in the government building of the St. Louis Exposition. Abbe concludes that those malignant cells which have escaped destruction and retrograde change, show a striking quiescence, which may mean death of the vital force which makes them malignant. The author believes that on the theory referred to in Chapter VII. under the head of Physical Effects of Light, this would mean that the malignant cells which have lost their innervation and grown wildly have returned to more nearly their

proper atomic motion under the influence of the stimulus which has been imparted to them by the particles of the atoms of radium. It is not known what constitutes the malignancy of the cell, but the author believes that the explanation is to be found in a physical condition rather than

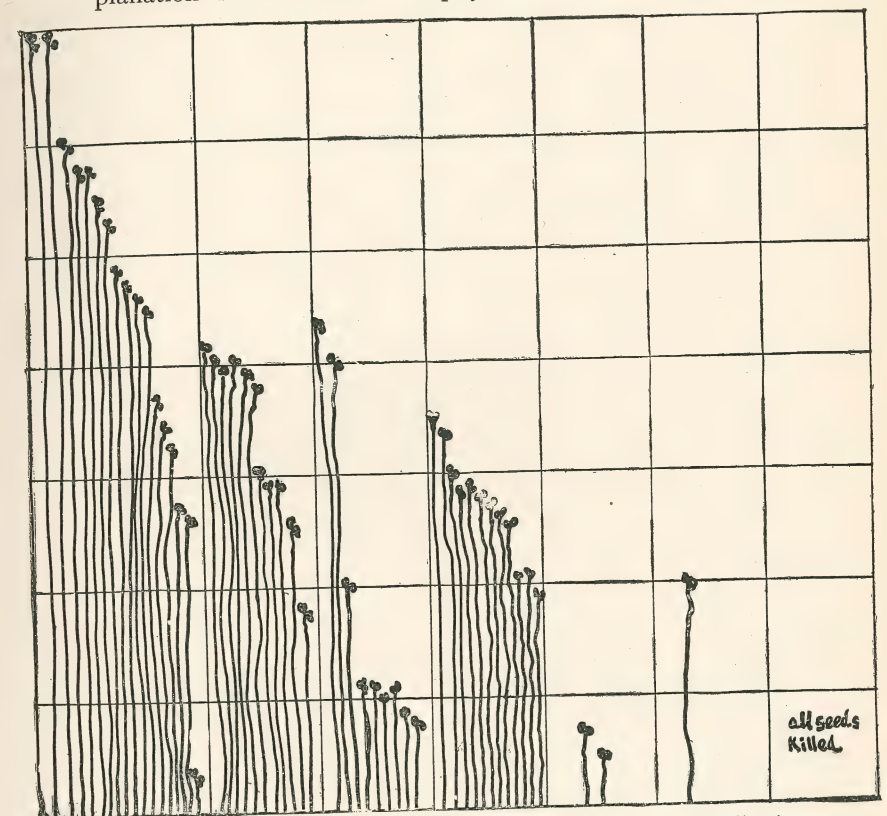

Fig. 49.—Diagrammatic representation of seed growth following exposure to radium rays; 20 seeds in each exposure; I., without exposure, 17 seeds grew; II., exposure for 2 days, 11 grew; III., 3 days, 9 grew; IV., 4 days, 12 grew; V., 5 days, 2 grew; VI., 6 days, 1 grew; VII., 10 days, none grew.

in that of a germ origin. It is in accord with much of observed fact, as to the effect of extreme stimulation in causing the destruction of some cells, and moderate stimulation a

regenerating effect upon others that they may be brought into the line of orderly growth again. In connection with the striking quiescence shown by malignant cells, Abbe states that one is reminded of the seeds which do not grow and the meal worms which are arrested in their development for an indefinitely long period. These experiments of Abbe's are notably scientific and convincing. They cannot but serve to stimulate careful clinical observation and experimental investigation. The need is for larger quantities of radium of greater radio-activity. In this connection there is introduced a diagrammatic cut showing the action of radium upon the development of germinating rape seed, for the use of which the author is indebted to the courtesy of Dr. Robert Abbe.

Radium in Malignant Diseases.—In September, 1903, the author in a paper on radium read before the American Electro-therapeutic Association, reported two inoperable and incurable cases in which treatment had been instituted by means of radium, one gramme of 7,000 radio-activity.

One, a case of sarcoma involving the left cheek, entire buccinator region and the mucous membrane of the lower left maxilla region, from the extreme angle of the jaw, extending upward and along the ramus of the jaw; the other, an inoperable primary pelvic case of epithelioma, involving the cervix, anterior and posterior vaginal walls; almost to the introitus, rectum, bladder and both broad ligaments. Both cases have been under treatment, the first for a month, the second for three months, by means of the X ray and ultra-violet light and both had been declared inoperable by the best surgical talent.

Similar cases, also two of cauliflower excrescence, all frankly inoperable, have been treated since. In every instance there has been an amelioration of the symptoms at first, i.e., control of pain, diminution of hemorrhage and discharge, lessened odor, lessened induration of affected parts, improved appearance of sore and a sense of well-being on the part of the patient.

During the year similar observations have frequently been made in the same class of cases, but the author wishes to assert in the most emphatic manner that there has been obtained no result which will warrant the belief for one moment that radium possesses any specific action in cancer. For a few weeks an improvement has invariably been noted, characterized by diminished pain, discharge, hemorrhage, odor and a sense of well-being. In some instances this has been marked. The symptomatic improvement is, however, evanescent. In a few weeks to one or two months the symptoms return with renewed vigor and the progress of the case is steadily downward, death ensuing from exhaustion.

The same is true of the X ray in these desperate inoperable pelvic or other internal cancers, and the author takes the occasion to say that every case of this character which she has had under care within the past three years has terminated fatally. Death has come as the result of the profound exhaustion just as it does naturally. That these patients have been made more comfortable for periods of time, greater or less, have experienced partial relief from the distressing syndrome, and that they have had greater length of days is admitted. The result obtained by Abbe in the case of giant cells sarcoma with a much higher radio-activity is encouraging. But despite the improvement the giant cell element remains.

While this is true, it does not follow that radium and for that matter other radio-active bodies are devoid of therapeutic value.

A case of rodent ulcer of eighteen years standing under care at this writing is doing so well that a favorable result is hoped for.

In a desperate epithelioma involving the loss of one eye and almost all of the nose, the patient had from three to four months of almost complete relief from pain and a sense of well-being foreign to her. But the story was just the same. After these months of relief of symptoms and apparent improvement in physical conditions, retrograde changes devel-

oped actively. Despite this, however, exposure to the radium rays always gave relief. The reaction became, however, very extreme toward the last of its use, evidenced by swelling and intense redness of the part and a sense of general malaise.

From the first, the author has observed the pain-relieving property of radium, a property held in common with electricity, suitably applied, light and the X ray. In the physical unity of the latter is to be found the explanation of the unity of physiological action and therapeutic result. The author stated a year since that from the physical properties and physiological effect of radium a therapeutic action was predicated. This is still true but not in such extensive malignant processes as reported.

During the past year two cases of anal fissure, the one had been referred for operation after months of classical treatment, but was unwilling to have it done, recovered completely in the course of about two weeks after beginning the use of the radium; the other of less long standing completely recovered in a week's time. The author has for a number of years established healing in these anal fissures by the use of rectal bipolar applications of alternating currents, the secondary of a magneto-induced, the sinusoidal or by the use of vacuum tube discharges, but the result was obtained in much less time by the use of the radium. From the ease and simplicity of its applications it lends itself to many conditions of this sort.

Holzknecht authorizes the statement that radium causes the disappearance of cutaneous telangiectases, obliterating the dilated vessels. The practicability of utilizing the effects of radiant activities for the relief of pathological conditions involving no such distressing syndrome nor lethal results as almost invariably mark the termination of malignant growths, should not for a moment be lost sight of. Radiant energy lends itself to the relief of many such conditions.

The hydro-oxid of thorium can be procured in large quantities at a moderate price, a sac of caoutchouc can be filled with it and then placed over the diseased part. It may be a neuralgia, a recent sprain, a contusion, a superficial non-malignant skin lesion, an anal fissure, it matters not save that it must be remembered that thorium is very feebly radio-active as compared with radium, the latter being 1,000,000 times more active. Ulcerated areas may be bathed with a solution of chlorid of sodium before exposing them to the action of radium. It has been shown by Hardy and Wilcox that the decomposition of iodoform in a solution of chloroform is accelerated by certain substances such as the chlorid of sodium. To the phenomenon of oxidation the physiologic action may be attributed.

All sorts of rays acting on the surface are able to destroy diseased tissue, purely by co-operation with the oxygen of the air or with something else which is on the surface and which is not in the deep-seated parts. If, says Sir Oliver Lodge, there could be carried into the deeper structures whatever it is that co-operates at the surface by injection either of radium or of some oxidizing solution to co-operate with the X ray, the outlook would be more hopeful. As the gamma ray of radium is identical with the latter its penetrating power could be utilized under these suggested conditions instead of the X ray. When radium radiations enter the tissues nascent oxygen or ozone is generated. Interchemic action alters the function of the part, tissue reaction is increased and health restored.

Induced Radio-activity in Therapeutics.—This naturally leads up to the use of waters which have been rendered artificially radio-active. Such radio-active waters have been used by different medical men in different parts of the world, but no sufficient well-authenticated clinical evidence has been accumulated to give the method a place among therapeutic measures "of good and regular standing." Its supposed therapeutic value has been the subject of considerable sensational newspaper report. This is not denying the method the grain of truth which on physical ground it undoubtedly possesses. It will be recalled that radium emanations furnish a

spectrum hitherto unknown and that their transformation to helium follows their enclosure in a Geissler tube through which an electric current is discharged. The unknown always offers the hope of something not yet attained.

According to Soddy[1] all the emanations of radium are instantly evolved in gas "and mixed with the air above the solution. Now let these emanations be removed by a current of air passing through the solution. The air with the emanations can now be stored in a gas holder in another room. Observations will show that one-half of the emanations will disappear every four days, and in three weeks no emanations of radium will be left; but the solution from which it was obtained has grown a fresh crop of emanation just as fast as the old ones disappear. That is, it takes about three weeks for the solution of radium to be as potent as it was in the beginning when the salts of radium were first dropped into it."

For the treatment of respiratory conditions Soddy suggested that "for an inhaler, an ordinary gas wash bottle provided with two taps could be used, so that there is no leakage of these precious and slowly formed emanations. From five to ten milligrammes of dry radium bromid should be introduced into the wash bottle and a few drops of water drawn in to dissolve it, the taps being immediately closed. For the first treatment, the first few bubbles of gas should be inhaled with a deep breath, gradually increasing the dose. Repeat this treatment every day. In this manner the emanations of radium and their radio-activity, which is inimical to germ life, would do their work at the seat of the disease."

The only way to determine beyond question the place of radio-active substances and induced radio-activity in the therapeutic armamentarium of the physician is to lose sight completely of all their sensational elements and subject experimental and clinical evidence to the most exact and rigorous tests known to physicists and physicians.

[1]British Medical Journal.

Receptacles for the Therapeutic Uses of Radium.—The author has uniformly used the salt of radium in its enclosing glass or aluminum tube; rather than any of the receptacles for that purpose. With glass tubes the action of the β rays is limited. These identical with the cathode rays, it will be recalled, do not pass through glass but do through aluminum.

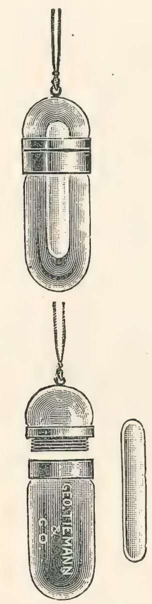

Fig. 50.—Radium Receptacle for the Stomach.

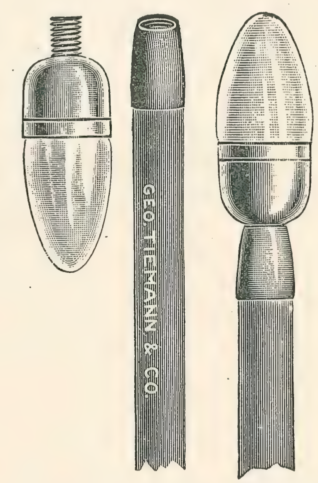

Fig. 51.—Radium Receptacle for the Œsophagus and Rectum.

Aluminum, on the other hand, limits the passage of the α rays. In this connection the reader is referred to Rutherford's table on a previous page as to the thickness of aluminum transparent to the different rays. Again appropriate thickness of lead prevents the passage of the penetrating gamma rays just as with the X ray. Radium, unenclosed, exposed to moisture loses its radio-activity. The accompanying cuts, however, show several different applicators on the market for the use of radium. In Figs. 50 and 51 are

shown the devices of Dr. Max Einhorn[1] for use in the esophagus, stomach or rectum. Fig. 50 shows the enclosing capsule and radium tube for the stomach, while Fig. 51 shows the capsule and flexible bougie separately and attached for use in the rectum. There is no clinical evidence to show that radium used within the stomach has been of any practical value, however.

[1]N. Y. Med. Record, March 5, 1904.

Fig. 52.—1, brass containing receptacle for radium; 2, box for containing this receptacle when carried in pocket; 3 and 4, applicators of solid silver; 5, handle for the same; 6, applicator made of lead to which No. 3 can be attached.

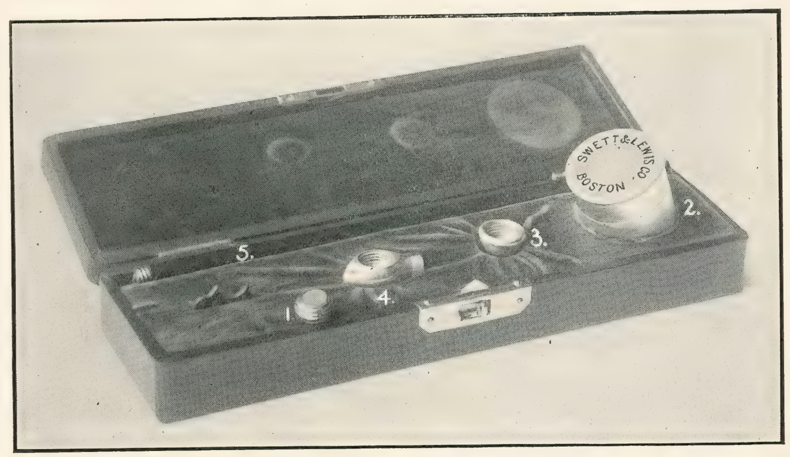

Fig. 53.—This is the same as the preceding figure save that it is smaller and applicator No. 6 is omitted.

Applicator Sets for the External Use of Radium.

CHAPTER XX.

Fluorescence, Fluorescent Stimulation, Sensitization. Therapeutic Uses in Cancer, Lupus Vulgaris, Condylomata, Indurated Chancre and Malaria.

Fluorescence and Fluorescent Stimulation.

Fluorescence.—In studying the phenomena observed by Herschel and Brewster, i.e., that some varieties of fluorspar, and also the solutions of certain substances, when looked at by transmitted light appeared colorless, but when viewed in reflected light presented a bluish appearance, Stokes discovered that under certain circumstances the rays of light are capable of undergoing refrangibility. He found that this phenomenon was characteristic of a large number of bodies, but from its having first been studied in fluorspar, he gave it the name of *fluorescence*.

"There can be no doubt that the property possessed by certain substances of appearing self-luminous, when exposed to the direct action of light rays, was a phenomenon known to the ancients. The discovery in tombs of 'tear bottles,' which are fluorescent to a remarkable degree, and the occasional reference to this peculiarity noticed in the works of Pliny, Albertus Magnus, and other writers of the Western School of Civilization, would be sufficient to substantiate such a claim even if more direct evidence were wanting. To the Oriental School of Philosophy the honor belongs of having initiated the first philosophic, if not truly scientific, research into this subject. So accurate are many of their observations that, stripped of the superfluous and tawdry tinsel with which Eastern mysticism and religious

superstition loves to cloak its discoveries, the facts recorded in the fourth book of the 'Talbath Rayoal' could well pass as an exposition of the present position of modern knowledge of the subject. A liberal acquaintance with phenomena dependent on reflection, refraction, diffusion and absorption of luminous radiations, coupled with that of fluorescence, allowed them to imbue the uneducated mind of the public with a superstitious reverence for the occult powers of the teacher, and the necessity for a very strict observance of the ritual enjoined for the prevention and cure of diseases, which modern science has proved to be injuriously affected by ultra-violet radiations. In descending to more modern times we remark that Vincenzo-Casirolo, in 1602, records some observations of a similar phenomenon noticed in connection with Bologna phosphorus—an impure sulphid of barium obtained by calcining sulphate of baryta with gum and other resinous exudates. The discovery of Canton's phosphorus (calcium sulphid) and Homberge phosphorus (chlorid of calcium) stimulated further research in this direction, and much speculation as to its causes was indulged in. Muschenbroeck's discovery of a similar property in petrol and Häuy in fluorspar were the next to attract attention; but it was not till the year 1852, when Stokes published his experimental researches on "Changes of Refrangibility of Light," that the true cause of the phenomenon, previously termed "epipolic dispersion," was arrived at. He also succeeded in demonstrating this property in many substances not popularly recognized as fluorescent, i.e., wood, horn, bone, leather, skin, the claws of animals, and the foliage of certain plants. Among the better known fluorescent substances—quinin bisulphate, esculin, petrol, tolché, gelsemin, fluorescin, turmeric (curcuma), the platino-cyanids and the salts of uranium may be mentioned. Platino-cyanids are potentially active only in the solid state; others, like the salts of uranium, are more fluorescent as solids than they are in solution; turmeric, on the other hand, fluoresces equally well under both conditions; while naphthalin red, esculin and

quinin are most active in solution. The fluorescence of some substances only appears when they are suspended in an acid solution, others when dissolved in an alkaline menstrum. The transmutation of the more refrangible rays, effected by turmeric, explains its daily use by the Hindus to protect the skin against the ardent suns of the Tropics. Its use is also enjoined in the 'Talbath Rayoal' for a host of eruptive cuticular affections attributable to or aggravated by exposure to the ultra-violet radiations."[1]

Fluorescence Depends upon Absorption of Energy at One Wave Length and Emission at a Greater Wave Length. —The phenomenon of fluorescence depends upon the ability of some substances to absorb energy of radiation at one length, and to emit it as a radiation at a greater wave length, or, in other words, to have set up in their heavier molecules slower vibrations. This absorption does not occur at all parts of the spectrum, but may be in several parts, generally contiguous to one another. It may take place at the one end or the other of the spectrum. From the chemical end the ultra-violet frequencies are absorbed by the atmosphere or glass, while at the other end red is absorbed by alum, for example. The energy of radiation which the fluorescent substance emits is not monochromatic, nor is it of all wave lengths like white. For example, light waves are absorbed by the body, to be emitted as heat rays. Similarly the very quick and short frequencies or ultra-violet rays may be converted into slow visible rays. This absorption and emission is distinctly selective. The phenomenon of fluorescence is also dependent upon temperature. It was proven mathematically by Kirchhoff[2] that for every ray of light the relationship between the emissive and absorptive powers of all bodies is alike at uniform temperatures. It was this fact that led to the investigation of the chemical composition of the sun and its atmosphere. The spectra of absorbed light shows only lines or bands, but emission spectra may be unbroken in lines

[1] Medical Electrology and Radiology. Editorial, April, 1904.
[2] Spectrum Analysis, Landauer.

or bands. The immediate emission of absorbed light is characteristic of fluorescent substances. If they retain their luminosity, due to absorption of energy of radiation of a given wave length, the phenomenon is known as phosphorescence. Becquerel proved that all solid fluorescent substances were also phosphorescent, but only for a short time. This was done by means of an ingenious device, to which he gave the name of phosphoroscope. If the absorbed light is retained long enough to remove the fluorescent body to a dark closet, the phosphorescence can be observed by viewing it after closing the eye for a few minutes. Some substances emit their light so quickly, however, that the only way in which to demonstrate that they still retain absorbed light is to use a phosphoroscope, by means of which the observation can be made immediately. In this manner, the phosphorescence of substances before unsuspected of presenting the phenomenon, as iceland spar, for example, was established. Fluorescent substances or bodies are self-luminous throughout the period of their illumination. The color of the light emitted by them is not that of the energy of radiation or wave length absorbed, nor is it the same as the color of the substance itself, but of the color of the wave length emitted. It may be blue, green or red, as will be seen subsequently. In other words, a fluorescent substance is to be looked upon as a Radiant Frequency Transformer. Fluorescence is usually due to the absorption of that energy of radiation characterized by short wave length, as the ultra-violet. The light produced in the fluorescent substance may be of longer wave length than in the exciting light, but, as a rule, is never of shorter than the exciting energy of radiation. Eosin, fluorescin and naphthalin red are not governed by the same law, and the fluorescent light from these substances can contain shorter frequencies than the light absorbed. The color of fluorescent bodies depends upon absorbed light, while the color of objects ordinarily is due to reflected light. In phosphorescent substances the emission of light may assume different colors, as, for example, in sulphid of calcium and sulphid of strontium. Absorbed light is capable of producing chemical effects, decomposition, for example, and upon this physical fact photography is based. Absorbed light may also, under certain conditions, produce mechanical results. This is beautifully shown in Crookes radiometer, described in Chapter II.

In the mineral kingdom silicate of zinc, commonly known as willemite, acts as a radiant energy transformer, fluorescing under the influence of ultra-violet rays, Roentgen and Becquerel rays, and also under the influence of vacuum tube discharges. This substance has been in common use among physicians to a greater or less extent since the discovery of Roentgen, and especially since the more common use of ultra-violet light, for the purpose of testing vacuum tube discharges from a source of high frequency and high potential. It functions as a radiant frequency transformer under these influences. This has led to the erroneous idea that in vacuum tubes the physician has a source rich in ultra-violet light. Such is not the case, however, and the phenomenon is due to the high frequency discharge, as shown in the chapter devoted to Vacuum Tube Discharges. The fact of its so functioning indicates the near kinship of light and high frequency currents.

Electrical and luminous vibrations do not differ physically other than by the frequency and wave length. The work of Tesla, supplemented as it has been by many other brilliant experimenters, resolves itself simply into raising the frequency of an alternating current until the rate is equal to the velocity of light without heat. Currents of high frequency and high potential, by reason of their physical laws and physiological action, stand in close relation to light energy, without which light would not exist. The light of the aurora is very rich in rays of light refrangibility, as are also sources of high frequency and high potential currents.

Fluorescence of Quinin and Other Substances.—When a beam of the sun's rays is focused, by means of a long focus quartz lens upon a solution of quinin sulphate con-

tained in a test tube or a glass trough, a beautiful cerulean cone of light is formed. This is much the brightest on the surface, diminishing in intensity as the light beam penetrates the liquid. This fluorescence is due to the absorption of certain rays. But when rays of light have passed through a sufficient thickness of a fluorescent substance they lose thereby the power of exciting fluorescence when they are passed through a second layer of the same substance.

This can be easily demonstrated by taking a test tube containing the solution of quinin and placing it in another and larger test tube of the same solution, or within a glass trough containing the solution. In the first instance, the fluid is brightly luminous or fluorescent upon exposure to the sun's rays or an arc light, but when immersed in a second tube containing the solution of quinin there is no fluorescence upon exposure to the source of light. This also results from a comparison of the absorption spectrum of a fluorescent substance with the appearance presented by this substance when the spectrum falls on it. Fluorescence indicates the beginning of absorption, and when it is most marked there is indicated a maximum of absorption. When quinin solution is placed in glass troughs with parallel sides, the phenomenon is seen upon placing it in different parts of the solar spectrum. There is no change observed in the less refrangible parts of the spectrum, but (see colored plate) from a point about half way between the lines G and H to some distance beyond the extreme range of the violet, rays of a beautiful sky blue color are seen to proceed. The impregnation of a paper with a solution of æsculin causes the invisible ultra-violet frequencies to become visible, likewise an alcoholic solution of stramonium, and canary glass, which is colored by means of a salt of uranium. Paper impregnated with barium platino-manganid and exposed to the light fluoresces with a beautiful green color. Here the absorbed light is emitted at a longer wave length than with quinin. Fluorescin in soda requires but a few drops to a large beaker of water exposed to the sun's rays or an arc

light, to produce beautiful fluorescent clouds of a green color, and upon agitation shows the fluorescent coloring throughout the whole vessel. These phenomena are produced by a diminution in the refrangibility of the frequencies outside of or beyond the violet, which are ordinarily too refrangible to affect the eye. Many of the more refrangible rays are cut off by means of glass, none of the ultra-violet frequencies of less than 30 micro-centimetres passing. Quartz, however, is much more transparent, and permits the passage of higher and shorter frequencies than 30 microcentimetres. By closing an aperture in a dark room with blue glass, and permitting the light to fall upon a piece of canary glass, which, as has been shown, is a fluorescent substance, it instantly appears self-luminous by reason of the emission of the energy of radiation, which it has absorbed, but at altered wave lengths. If a freshly prepared solution of chlorophyll in ether is poured into a test tube half filled with a solution of quinin sulphate, the two colors will appear green and colorless respectively in transmitted light, but blood red and sky blue in reflected light. By using a prism and trough formed of quartz, and receiving the spectrum on a sheet of paper, which has been washed with a solution of sulphate of quinin, two juxtaposed spectra may be seen. The spectrum on the part treated with the quinin sulphate will be seen to extend beyond the line H to an extent equal to that of the visible spectrum, and in it may be seen dark lines analogous to those in the ordinary spectrum known as Fraunhofer's lines, and indicating absorption. While the violet and the ultra-violet in most instances are the frequencies which undergo refrangibility, the phenomenon is not confined to them. A decoction of madder in alum, for example, gives yellow and violet light from about the line D to beyond the violet, and an alcoholic solution of chlorophyll gives red light from the line B to the limit of the spectrum. The more refrangible frequencies are produced in these instances by increased refrangibility of the yellow, green and blue frequencies. Magdala red forms an

exception to the rule, as a solution of it in a rectangular glass vessel upon exposure to a solar spectrum presents the phenomenon of an orange, red, yellow fluorescence, even in the red part of the spectrum. There are also some substances of no especial illuminating power, which present peculiar phenomena. Characters may be traced on paper with a solution of stramonium, for example. In daylight they are almost invisible, but upon illumination by the flame of burning sulphur or carbon bisulphid, become clearly visible instantaneously. Fluorescence is the most common of all the allied phenomena, i.e., phosphorescence, fluorescence, calorescence, investigated by Stokes, Leonard, Kundt, and others.

By fluorescence, then, there is understood the luminosity of substances exposed to the action of light, which lasts only as long as exposure to the light activities. It is an effect of absorbed light. The action which produces fluorescence in a quinin solution, for example, is due to the very short and high frequencies, but the emitted frequencies or fluorescent light are of the longer and slower frequencies, greater wave lengths than any of the absorbed frequencies, and by no chance none of the shorter wave length. The exceptions to this law have been referred to on a previous page.

Fluorescence, although not confined to them, is especially an attribute of ultra-violet rays, Roentgen and Becquerel rays. These are the vibrational activities which produce the most marked physiological action. The physiological action of these different rates of vibrational activity unquestionably has a common source. Their power to produce fluorescence, or to act as radiant frequency transformers, would seem to indicate this. As the phenomenon of fluorescence is produced by high frequency discharges, it would seem to have a place in the same category as the ultra-violet, Roentgen and Becquerel rays.

Fluorescence of the Blood and Lymph Serum.—The phenomenon of fluorescence is not confined to the mineral and vegetable kingdom, but is shared by the animal kingdom as well. The fluorescence of the blood was demonstrated in 1866 by Dr. Henry Bence Jones.[1] He found during his investigations that the blood in all the organs of men and guinea pigs contained a fluorescent substance to which he gave the name of "animal quinioidin." In this fluorescence of the blood and the lymph serum in normal living tissue is to be found, the author believes, the keynote of the response of the living organism to the action of radiant energy. In this capacity of the human tissues, blood especially, to function as a radiant energy transformer, that is, to absorb light and emit it again, evidenced by its fluorescence, is found at least one conclusive reason for the physiological action of light.

Action of Fluorescent Illumination upon Infusoria.—The action of fluorescent light, obtained by the illumination of phenylacridin, on infusoria was tested by O. Raab, at the suggestion of H. von Tappeiner.[2] The subject of this experiment was Paramœcicum caudatum in a suspended drop culture, placed in a damp chamber. But first, it had been shown that paramœcia, in an acridin solution, 1 in 20,000 die in sunlight in 6 minutes, and in diffused daylight about 60 minutes; but if kept in the dark, they were alive after 6,000 minutes, i.e., 100 hours. A 1 to 800 culture in an eosin solution, placed in the green part of the spectrum of an arc light, which was broken up by means of a prism, showed after from 2 to 4 hours' exposure all degrees of injury even to death. But little or no effect was produced upon the culture by the other parts of the spectrum, which are not absorbed by the eosin, at least but imperceptibly, and, therefore, do not produce fluorescence in it.

With a paramœcia culture in an acridin solution, 1 to 20,000, arranged so that all the light reaching it had to pass through a 4 to 5 cm. layer of concentrated acridin solution 1 to 500, the light no longer took effect, and the paramœcia

[1]Medical Times and Gazette, London, August, 1866, pp. 163-167.
[2]Muenchner Med. Wochenschr., 1900, No. 1, p. 5, and Zeitschrift 8. Biologie, Vol. XXXIX.

were healthy after a week, even when exposed to sunlight. Upon repeating the experiment, but taking a quinin solution as a screen instead of the acridin solution, the light acted disastrously as usual. This was due to the fact that the quinin absorbed the ultra-violet waves which, with the acridin, were inactive, the latter absorbing the violet rays only. The fluorescent light or emitted light with the quinin solution was active by reason of the more intense fluorescent stimulation, i.e., ultra-violet absorption and the emission of the frequencies of the blue region; or, in other words, the same frequencies as those absorbed by the acridin. When a solution of a fluorescent material, acridin, quinin, or whatever it may be, is placed within a solution of the same material, then the fluorescence of the first solution is either absent or much less marked because the first solution has absorbed the frequencies which, by reason of its physical nature, it is capable of absorbing before they reach the second solution, and as the fluorescent or emitted light is of a longer wave length, it follows that the fluorescent medium is not capable of absorbing it.

Von Tappeiner concludes from these experiments that it is not the fluorescent light which is harmful, but the process of stimulation induced by the fluorescence itself. The results of the experiments were summed up by von Tappeiner, as follows: "Light becomes highly injurious to paramœcia in the presence of acridin, phenylacridin, eosin, and quinin, in solutions which, of themselves in the dark, are little if at all poisonous."

It follows, therefore, that this action of light is very closely related to the ability of the substances mentioned to function as a radiant frequency transformer or to fluoresce.

The injury done is in the process of production of the fluorescence, as would be expected, for fluorescent substances do not function upon the withdrawal of the stimulus; or, if by chance, they emit light after the stimulus, i.e., exposure to an exciting source, light, the X ray or radium, it is of a phosphorescent nature which, as will be shown, has

no bactericidal action. According to Raab, the phenomena, i.e., the action of fluorescent stimulation upon the paramœcia caudatum, and upon chlorophyll, are the reverse of one another. In the former it results in the death of the paramœcia, while in the latter it is the condition of continued life.

The view is held by Tappeiner in common with the author, that this kind of light comes into play with those animal organs and fluids which have the capacity for fluorescence, as the skin, retina, aqueous and vitreous humors of the eye, blood and lymph serum. May they not, in other words, be regarded as radiant frequency transformers? In the absence of sunlight, it is impossible for them to function normally, hence disease and death. Or fluorescent substances may get into the body by way of food or drugs, which abnormally increase the fluorescent stimulation and cause an irritation of the skin. The skin inflammation from the use of buckwheat, both in man and beast, noticed by Wedding, von Tappeiner surmises is to be accounted for in this way, and to the author's mind it seems rational to conclude that there is a posssible absorption or formation of fluorescent substances from the fodder.

The Action of Fluorescent Stimulation Analogous to the Action of Light Energy on Chlorophyll.—O. Raab believes that the action of fluorescent stimulation on infusoria finds its analogue in the action of light energy on the chlorophyll of plants, viz., that the light energy is converted into chemical energy. Chlorophyll is a fluorescent body, and in functioning as a radiant energy transformer the light energy is converted into chemical energy. The effect obtained from painting a diseased surface with a fluorescent substance, eosin, for example, would insure at the site of disease a greater stimulation than from the unabsorbed light energy alone, for under the stimulation of absorption there is also emission, evolving a much more intense light stimulation. Thus far this action of fluorescent substances has been regarded as a process of transformation. There is no ques-

tion but there is a more profound chemical action, than by the same frequencies of light energy unaided. Regarded as a process of transformation it does not seem essential that it should always be a step-up transformer. With eosin such is the case, however, and the higher degree of energy of radiation, the green, is converted into still higher, and in the process of giving birth, as it were, to other frequencies, shorter and higher than it absorbs, there is increased energy of action. To the author's mind this therapeutic use of fluorescent stimulation, or with some substances a sensitization, finds its analogue in the use of oxidizable metals at the anode when connected to a source of continuous E. M. F. Here the new-born or nascent salt of copper, for example, acts much more energetically than any preparation of copper which could be applied to the foci of disease.

Just so long as fluorescent substances are applied to diseased surfaces, or placed within mucous cavities, they unquestionably function as radiant frequency transformers, but when taken internally, and the body is exposed to the action of light, the X ray or radium, the problem is a different one. It seems reasonable, however, to suppose that fluorescent substances should function as radiant frequency transformers, and in so doing, impart healthful stimulation, if of themselves they are not injurious to the living organism, to certain diseased processes. That this is true of quinin in malaria, for example, is abundantly proven, and also that the normal fluorescence of the blood is absent in this disease.

This was a subject of most careful investigation by Drs. Rhoads and Pepper[1] over 30 years since. They found that the fluorescence of the blood in malaria was diminished, and that quinin acted to restore its fluorescence to the normal standard. With this increase of fluorescence, the fever disappeared and the patient got well.

The experiments of Rhoads and Pepper followed the discovery of Jones, and resulted in the presentation of 12 cases

[1]Penna. Hospital Reports for 1868, pp. 269, 280; also Phila. Med. Times, Jan. 23, 1875, p. 259, etc.

of ague, in which they demonstrated that quinin cured by increasing the fluorescence in the blood of fever patients. Dr. A. F. A. King, of Washington, unearthed the record of these experiments and cases in a comparatively recent article upon "Sunlight and Malaria,"[1] which will be considered especially under the head of Sensitization.

Action of Fluorescent Stimulation upon Ciliary Epithelium, etc.—Analogous observations to these of von Tappeiner have been made by M. R. Jacobson and M. Jodlbauer.[2] The experiments of the latter have been upon ciliary epithelium, as well as upon the peptonizing and saccharizing ferments and upon certain toxins. The untoward action of the fluorescent substances used, just as with von Tappeiner's experiments upon infusoria, were only manifested under the influence of light.

The conclusion naturally reached is that the phenomenon takes place only under the direct influence of fluorescence. Von Tappeiner and Jesionek found that of all the substances experimented with (acridin and its derivations, eosin, climolin, harmalin, uranin, magdala red), eosin presents the advantage of acting energetically at the same time upon cellular elements, toxins and ferments. They, therefore, selected it with which to make some experiments as to the therapeutic value of fluorescence.

Action of Fluorescent Stimulation in Lupus, Cancer and Syphilis.—Their experiments were instituted at the clinic for skin and specific disease (dermatological and syphilographical) of the faculty of medicine, Munich. The subjects selected were those having infectious dermatoses, lupus, cutaneous cancers and syphilitic lesions, and the experiments consisted in frequently painting the diseased parts with a 5 per cent. aqueous solution of eosin, and exposing them immediately to the rays of the sun, or, in bad weather,

[1]The American Journal of the Medical Sciences, Feb., 1902.
[2]Therapeutic experiments with fluorescent substances by von Tappeiner and Jesionek, Semaine Medicale, Abst. in Revue Internationale Électrothérapie, Jan., 1904.

to the light of an electric lamp. The lesions were protected during the night by a dressing of boric acid water, or a plaster of oxid of zinc ointment.

They noted that in three cases of cancer of the face under the influence of the treatment, the ulcerated surface became covered again with good granulations, the lesions evoluting, as it were, toward a cure. In lupus, they found the action of this method so much the more energetic as the affected parts were the more accessible.

Superficial lupus patches, ulcerated or covered only with thin skin, were influenced by the treatment. The effect of medication was almost nil in deep-seated lupus nodules situated in the midst of healthy tissue. Equally good results were obtained in 10 cases of condylomata of the genitals in women, and in 2 cases of indurated chancre. In this report the frequency and time of the exposure of these various cases to fluorescent stimulation was not given by the authority quoted.[1]

Fluorescent Stimulation in Malignant Conditions, Hodgkin's Disease, etc.—Morton[1] has used fluorescent stimulation in the treatment of malignant conditions and Hodgkin's disease. He utilizes quinin, esculin, fluorescin, etc., in connection with (1) the Roentgen ray, and (2) radium. Quinin solutions fluoresce outside the body in acid solutions, esculin froxin, fluorescin, resorcin and eosin fluoresce in alkaline media. These substances are all capable of greater fluorescence when in a very dilute form, which renders their use innocuous. Because of the alkalinity of the blood esculin and other alkaline solutions would seem to be the better ones to use; but, on the other hand, experiments have shown that the ultimate products of quinin as formed in the excretions are still capable of fluorescence. Esculin passes through the organism without being decomposed. The addition of sodium chlorid increases its fluorescence. Because of the energy of radiation, blue and violet, which quinin and esculin

[1]N. Y. Med. and Philadelphia Med. Journal, Feb. 13 and 20, 1904.

emit, Morton has used them principally, the former in 5-grain doses, the latter in a dose of a grain, given in dilute solutions, preferably a few hours before treatment. Seven cases have been treated by Morton and under his advice. Five are reported recovered and two dead. One of Hodgkin's disease was under treatment for 5 months, and had 62 X ray exposures. He gained 14 pounds, and is considered recovered. Three primary breast carcinomas, one complicated by a recurrent carcinoma in the opposite breast, were similarly treated, and one reported cured to date. In one case 4 months only had elapsed since first treatment, in another 5, and in the third a year. In a case of rodent ulcer of the cheek, the size of a quarter-dollar, with continuous discharge and crusts, the ulcer healed over with a new skin in 18 days. The sixth case, extensive papillomatous growths in the abdomen, had been operated upon two months prior to coming under treatment. An ovarian tumor, the size of a derby hat, was found with abundant papillomatous growths attached to various parts of the abdominal peritoneum with much ascites. No attempt was made to remove the tumor, as the patient was very much emaciated, and death believed to be imminent. The patient was suffering extremely when treatment commenced March 21, 1903, from pain in the left side of the abdomen, paroxysmal, lasting several hours, and causing intense nausea. Urination was difficult, often recurring every half an hour, and the patient was very weak, unable to walk more than two blocks. Five to 10 grains of quinin bisulphate were administered daily, and exposures to the X ray hard tube, 20 minutes each, were made three times a week. In less than a month, the record reads, "not a pain or an ache," able to walk from 10 to 12 blocks without discomfort, to sleep all night, and no trouble whatever in micturition. On June 6 the surgeon opened the abdomen. He found that both ovaries had been the seat of papillomatous growths, and that these were more scattered over the peritoneum than he had first thought. He removed the primary tumors and hand-

fuls of the exuberant mass, along with quarts of bloody ascitic fluid. A 50 per cent. peroxid of hydrogen solution was used, followed by copious washings of saline solution. She made a beautiful recovery, resumed the X ray fluorescent treatment during the summer and autumn. Six months later had gained 35 pounds, felt strong and well; no consciousness of abdominal trouble. Morton believes that the violet and ultra-violet radiations within the abdominal cavity were the controlling factors in determining the patient's recovery.

Sensitization.

It has been suggested that these substances act as transformers. The author is convinced in the light of recent studies and experimental work upon the part of a host of original investigators, that the better, and fully as illustrative a term, is that of "sensitization." The sensitized tissues are in truth made sensitive to rates of vibrational activity of oscillating light energy physically capable of greater penetration than those which act not dissimilarly upon normal or unsensitized tissues. By reason of this sensitization the action is not only much more energetic, but also much more deeply situated.

In the following pages are given the results of experimental work bearing upon sensitization (which has been referred to under the action of light energy upon bacteria), the conclusions of different investigators and also the hypothesis of S. G. Busck, of Finsen's Light Institute, as to the influence of daylight upon the action of quinin in weakening or destroying the malarial plasmodium.

It is very clearly shown by the mass of observed facts that it is the blue-violet and the ultra-violet which possess to a great extent bactericidal power, and the reason for the great difference between their action on the one hand and that of the longer, slower and less refrangible frequencies on the other, must undoubtedly be due to the absorbing

power of the former as against that of the latter, for the stronger the absorption the greater the fixation of energy and action. The manner of the transformation of the absorbed frequencies depends upon the periodicity of the swing of light corpuscles or rate of vibration. Corpuscular disturbances transmit energy from an active phase of matter to a passive or receiving non-vibrating phase. This transmitted energy in the case of the very rapid corpuscular disturbance of the short and high frequencies gives rise to a chemical process in the protoplasm of the bacteria, which causes their death; while transformation of the energy of those corpuscular disturbances of longer and slower frequency into heat or some other form of energy takes place, which under the given circumstances is carried off without harm to the bacteria.

The absorption of light as well as the mode of transformation depends not only on the physical nature of the frequency, i.e., its length, periodicity and amplitude, but also upon the properties of the substance by which it is absorbed.

By altering the properties of the substance, there will result a change in the action of light energy on said substances. It follows, therefore, that if in any way it is possible to alter the properties of the bacterial protoplasm, or perhaps only the surrounding culture medium, without thereby killing the organism, there would be established a condition by which it would be possible to obtain a different action from the usual one on the bacteria by the different frequencies of the spectrum. If this could be done for bacteria, it would be equally good for all living organisms, animal as well as plant life.

Sensitizers in Photography.—Vogel[1] in 1873 showed that by the addition of certain substances the so-called sensitizers to the ordinary photographic bromid-silver-gelatin plates. the latter can be made sensitive to rays or frequencies of the

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[1]Quoted by Busck, Lichtbiologie.

spectrum, which before only had a very small action, or perhaps none at all; and he succeeded in producing plates, which were as readily influenced by red and yellow frequencies as by those of greater refrangibility (color sensitive orthochromatic plates).

This discovery of Vogel has been extensively made use of in photography during the past thirty years, but no satisfactory explanation of the phenomenon has been found. It is not yet decided whether it depends on different conditions with regard to absorption or an alteration in the manner of transformation of the energy of the frequencies in question.

Certain biological phenomena have been considered analogous to photographic sensitization.

Among the fluorescent coloring substances there are several, of which chlorophyll is the most common, which are of very decided importance. These coloring substances are, according to Busck, to be considered as sensitizers analogous to that of Vogel, i.e., substances which only transmit the light energy to the coloring matter of the leaves, without themselves taking any direct part in the taking up of CO_2, or the giving off of oxygen.

In the 70's, Engelmann[1] drew a similar parallel, and he showed experimentally that the maximum activity with reference to the separation of oxygen is to be ascribed to certain frequencies according as the chlorophyll of the plant in question contains this or that coloring matter.

At the International Botanical Congress in St. Petersburg in 1884, the same thought was brought out by Timiriazeff,[1] who asserted that there was a perfect analogy between the significance of the chlorophyll with regard to the carbonic acid assimilation of plants and that of the colored sensitizers in the photographic process. According to the experiments of Becquerel, 1874, chlorophyll also possesses sensitizing action on photographic plates.

[1]Quoted by Busck, Lichtbiologie, Mitteilungen aus Finsen's Med. Lysinstitut in Kopenhagen, Heft VIII., 1904.

"In the pharmacological laboratory in München, Tappeiner[1] and his pupils, Raab,[2] Danielsohn,[3] Jacobsohn,[4] and Ullmann,[5] have undertaken during the last 5 years a series of extraordinarily interesting experiments with regard to the action of various fluorescent substances in light and darkness. Raab found that infusoria (paramœcium caudatum) even in very dilute acridin solution dried considerably sooner when standing in the light than in darkness, and sooner in direct sunlight than in diffuse daylight. The same was the case in experiments with other fluorescent solutions. Raab sums up his experiments as follows:

"(1) The action of daylight is very harmful in experiments with acridin, phosphin and eosin.

"(2) This depends on the production of fluorescence.

"(3) The most active rays are those which produce the greatest fluorescence.

"(4) It is evident that fluorescent substances have the power to transform the energy of the rays of light into living chemical energy.

"(5) It is evident that fluorescence also plays a part in the animal organism, though to a much less extent.

"In a later work Raab[6] says: Chinolin red and hæmatin solutions have the same action on paramœcium caudatum with regard to fluorescence as acridin and phosphin. The action of the non-fluorescent fuchsin and crystal violet solution on the other hand is not increased by light. He found further that sunlight had the power of causing localized necrosis (in the ears) of white mice, in whom previously eosin had been injected—a phenomena which he is inclined to consider as a burn in consequence of the great absorption of heat rays.

[1]Münchener Med. Wochenschr., 2 Jan., 1900, und 5 Nov., 1901.
[2]Zeitschr. f. Biologie 1900, Bd. XXXIX.
[3]Danielsohn, über die Einwirkung verschiedener Akridinderivate auf Infusiorien, Diss., München, 1899.
[4]Zeitschr. f. Biologie, 1901, Bd. XLI.
[5]Ullmann über die Einwirkung elecktrischen Bogenlichtes auf Mikro-organismen in Gegenwort von Fluoreszierenden Stoffen. Diss., Münich, 1901.
[6]Zeitschr. f. Biologie, 1902, Bd. XLIV.

Raab appears to see in these phenomena not only an action of light, but a highly poisonous activity brought out by the light from the different fluorescent substances. He remarks, however, that no increase in toxicity takes place in the fluid, when this is first exposed to light, and later, after the addition of paramœcia, placed in the dark. Contrary to this, Ledoux-Lebard[1] found that the active rays decompose the eosin and produce a substance that is poisonous to the paramœcia.

Jacobson[2] examined floating ciliated epithelium (from the pharynx of a frog) in various fluorescent fluids. The motion of the cilia ceased much sooner in the light than in darkness. A second experiment was made as follows: A subcutaneous injection of 2 cgm. of eosin in solution was made into a frog, which was kept in the dark 24 to 48 hours thereafter. Although the tissues of the frog were colored red, the ciliary motion was not affected. Jacobson thereafter prepared specimens of ciliated epithelial cells, and placed some in the dark and others in the light. In those standing in the light he noted the death of the ciliated epithelia after 3 hours, while those placed in the dark showed ciliary motion after 24 hours. After subcutaneous injections of 0.00015 pro gr. of body weight the frogs were seen to be strongly incited in direct sunlight. After 6 hours, paralysis of the hind legs occurred, and on the following day the animal was dead. After an injection of 0.0005 pro gr. of body weight local muscular paralyses were found after 2 hours, but heart action continued about 5 hours longer. Frogs injected with the same amount of eosin, but kept in the dark, did not show any signs of paralysis, and continued to live. Even doses of 0.002 pro gr. could be borne by the frogs without marked toxic symptoms when kept in the dark.

"By emptying the cavum cranii of frogs, and filling the cavity with paramœcium cultures, placing some of the specimens in the dark and others in the light, Jacobson found that light, even after passing through a layer of animal tissue, had the power to kill the paramœcia.

[1]Annales de l'Institut Pasteur, 1902, No. 8.
[2]l. c.

"While Tappeiner[1] compares these phenomena with those of photographic sensitization, with which we are familiar, Jacobson[2] explains the toxic action quite differently. He writes:

"(1) Light increases the toxic action of fluorescent substances on ciliated epithelia.

"(2) The action of non-fluorescent poisonous substances is not increased by light.

"(3) Non-poisonous fluorescent substances exert the same action on ciliary motion in the light as in the dark."

In discussing the influence of light energy upon bacteria, Chapter V., it will be recalled that this principle of sensitization was utilized by Dreyer, of Copenhagen, in Finsen's laboratory in a great variety of experiments. Dreyer regards the action of the substances mentioned as analogous to the sensitization of photographic plates. From his experiments Dreyer reached the conclusion that "by using certain sensitizers, micro-organisms and animal tissues may be made as sensitive, yes even more so, to the otherwise inert though relatively strongly penetrating yellow and greenish-yellow rays, as they normally are to the strongly active but slightly penetrating chemical rays." As sensitizers, Dreyer[3] used especially erythrosin (tetra-iodo-fluorescinatrium). This coloring matter extensively used in orthochromatic photography proved to be especially active in these experiments. These experiments are quoted in the chapter devoted to the influence of light energy upon bacteria. He used solutions of 1 : 5000 or 1 : 8000. As has been stated in considering the action of light energy upon sensitized bacteria Dreyer's experiments were extended to living organisms. By injecting erythrosin solution into the spinal cord of frogs, or by local

[1]Münchener Med. Wochenschr., Jan. 2, 1900.
[2]Quoted from Busck-Lichtbiologie.
[3]Mitteilungen aus Finsen's Med. Lichtinstitut, 1904, Heft VIII.

cutaneous injections in rabbits and men, he showed that the otherwise inactive frequencies of the spectrum may cause inflammatory phenomena in the same.

These phenomena of inflammation did not quite resemble, either macroscopically or microscopically, the characteristic light reaction, but they were plainly analogous. The differences seemed to depend on the depth to which the changes extended into the sensitized tissues, and to such an extent that thrombosis of the deeper vessels occurred. "If," says Busck, "this experimentation is correct, it would favor the theory which ascribes the above-mentioned phenomena to the direct action of light energy made possible by the presence of the substances in question; in other words, an analogy with the action of optical sensitizers on the silver haloids."

On the other hand, Jacobson,[1] among others, has declared his belief in favor of the more toxicological explanation. He considers the toxic action of the fluorescent substances as the determining factor, even though in some instances the toxicity may be so small as not to be noticed when the action of the light is removed.

Jacobson concludes that "poisonous fluorescent coloring matters are inactive," and this is based on experiments with only one substance, viz., esculin; while his study of poisonous, but non-fluorescent substances only embraces fuchsin. His experiments suggest, says Busck, an extended study of the subject, but they do not prove anything in regard to all other non-toxic or non-fluorescent bodies. Busck notes in this connection that some experiments which he undertook after the above was in print, gave the result that the Koch plate cultures of bacillus prodigiosus were sterilized about seven times as quickly in concentrated light that had passed through a filter of 5% potassium chromate, when the culture medium (agar) was colored with a dilute fuchsin solution 1 : 5000 as when uncolored. Busck concludes that the

[1] l. c.

question must for the present remain unanswered, whether death in the case is to be ascribed to the simultaneous occurrence of two injurious factors, the toxicity of the fuchsin and the bactericidal action of the greenish-yellow rays, or to the increased action of the light in consequence of the greater absorption. The author believes on physical, not experimental, grounds that the latter is the true explanation, and that it is possible, as suggested by Busck, that the difference between the two theories depends on the fact that "light reaction" and "toxicity" are not clearly defined. It is simply a fixation of radiant energy, but not of those frequencies which are so well known by their action upon silver bromid. Let there be placed suitable media in the path of radiant and oscillating energy, and it meets cessation, the waves do their work not in this instance the very short and high frequencies of oscillating light corpuscles upon particles of silver, but the longer and slower frequencies of oscillating light energy upon substances placed in their path capable of being acted upon by them, erythrosin, for example, which leave their record and come to rest. In this instance the record is that of a deep-seated inflammatory action upon the tissues placed in the path of the light energy. In this way the energy is stored, and "there is no higher achievement of human hands than the storage of energy."

Dryer formulates the following conclusions in regard to sensitization:

(1) The fluorescence is not the determining factor in sensitization, because there are substances which are strongly fluorescent, which, however, are only slightly sensitizing, or not at all so (esculin, fluorescin), and on the other hand, there are non-fluorescent substances which are capable of sensitizing (cyanin).

(2) Neither is the absorption the determining property, because there are fluorescent as well as non-fluorescent substances, which are very absorbent, which are, however, not sensitizing to the rays which they absorb.

(3) It is scarcely probable that the sensitizing depends

upon the formation of toxic products in the sensitizer during the exposure, which have a deleterious effect upon the micro-organisms and the animal tissues, because if a sensitizer, as, for instance, erythrosin, is first exposed to light for ten minutes, and thereafter immediately used as a sensitizer, its power in this direction will be greatly diminished. This is very clearly demonstrated by the following table:

Filter.	Time required to kill Nassula sensitized with Erythrosin sol. (1:8000) not exposed to light.	Erythrosin sol. (1:8000) exposed to light.
Rock crystal	12 seconds	18 seconds
Clear glass	12 "	25 "
5% nickel sulphate	12 "	30 "
Blue glass	36 "	135 "
5% potassium chromate	12 "	30 "
5% potass. bi-chromate	12 "	70 "

It cannot be regarded simply as a coincidence that almost all the coloring substances which in the experiments referred to were found to be active were more or less fluorescent. It must be understood, therefore, from the first two points formulated by Dreyer, that neither the fluorescence nor the absorption alone is the determining factor. Both are evidently of importance. If the frequencies of oscillating light energy of the yellow and green regions of the spectrum were not absorbed they could not exert any deadly influence; or, in other words, they could not do any work. As it is the presence of the chlorophyll which facilitates the absorption of the energy, governing plant assimilation and disassimilation, so do these coloring substances facilitate the absorption of the strongly penetrating energy of the spectrum, determining thereby actual changes in the tissues. There are great numbers of photographic sensitizers which are non-fluorescent, nor does the fact that a coloring matter which possesses a profound sensitizing action on photographic silver haloids warrant taking it for granted that it may comport itself in the same fashion with living tissue for a sensitizer without further proof. It does not follow

even in photographic processes that the same substance shall in every instance act as a sensitizer. In one instance it may and another not, although the same substance often possesses both properties, besides there is a difference between optical and chemical sensitizers, just as there is between optical and chemical light intensity. It may be proven by further experimental work, whether in sensitizing living organisms, phenomena are not produced which though leading to similar results may be of an altogether different nature.

Tappeiner[1] extended his experiments with regard to sensitization into other provinces than those above mentioned. He showed that enzymes (papayotin, diastase, invertin) as well as toxins (rizan) were weakened by exposure to light, after the addition of certain fluorescent substances—as eosin or magdala red—while no noticeable change took place, if after the addition of the same substances they were kept in the dark.

The above-mentioned artistic sensitization is not only of great theoretical interest, but also has prospect of attaining an extensive practical importance, among other things, with regard to the therapy of light energy. Already in 1900 Tappeiner concluded his recital of the above-mentioned experiments with the following statement: "Conversely, by the incorporation or extraction of certain fluorescent substances, it may be possible, through the action of light, to obtain a therapeutically useful operation, so that then such substances may find a use, for instance, in dermatology, analogous to that of eosin and other fluorescent coloring matters which have been used empirically for the last 10 years as sensitizers in phototherapy."

In the treatment of lupus vulgaris and epithelioma by means of light the attempt has already been made in Finsen's Institute, as well as in Munich, as the reader will see in subsequent pages, to increase the action by sensitizing the diseased tissues.

[1]Berichte d. d. chem. Gesellschaft 1903, Bd. XXXVI., S. 3035, and quoted by Busck.

Tappeiner at this time is disposed to reject the term "sensitization," as he considers the phenomena altogether dependent upon the action of phosphorescent light, and replaces it by the term "photodynamy." Busck does not think it necessary to reject so familiar and illustrative a term as "sensitization." He considers it necessary, however, to give it as wide a significance in biology as in photography, where the term sensitization is used as a general name for processes of widely differing nature.

In this connection it is pertinent to recall the observation of Wedding in regard to the action on the skin of light or parti-colored beasts fed on buckwheat, when exposed to the action of light, a condition which does not appear when they are kept in the dark. Spotted animals, it will be remembered, are only affected on the non-pigmented areas. This phenomenon is well known to farmers (and within the author's knowledge occurred also in human beings when living on buckwheat flour). Finsen refers to it in his treatise on the action of light on the course of smallpox, and says, "We see, therefore, that the skin can be brought into such a sensitive condition that even a very small, under ordinary circumstances absolutely unimportant amount of light, is able to call forth such important lesions."

This, as is stated in a previous page, is believed by von Tappeiner to be due to the absorption or formation of a fluorescent substance from the fodder. Busck did not regard it as proven that the buckwheat contained a substance capable of sensitizing the skin, i.e., rendering it sensitive to the rays that otherwise have no action upon it. As almost all biological sensitizers thus far known are fluorescent, Busck thought that even with buckwheat it must be a fluorescent coloring matter peculiar to it. An analysis of buckwheat was undertaken for him by Professor Kofold, the Director of the Pharmaceutical College in Copenhagen, yielding the positive result that the ordinary, and especially the silver buckwheat contained a fluorescent red coloring matter, not found in the other grasses. This coloring matter, called by Professor Kofold "fluorphyll," is soluble in alcohol and ether, but not in water.[1]

Busck says, however, that the amount of fluorphyll thus far produced is too small to undertake any systematic experiments with regard to its sensitizing action. The few small tests which he made with but half a gram of the substance gave negative results. Because of the insolubility of the substance in water these experiments were rendered the more difficult. It is, therefore, not yet proven, he concludes, that the buckwheat exanthem is to be ascribed to the action of light on the sensitized skin; but the fact that buckwheat contains a fluorescent substance not found in other fodder evidences the correctness of the hypothesis. Suffice it to say that whatever the results of future experiments may be in this special direction, Busck considers, as does the author, that such a characteristic process so effective in its action as sensitizing must play a more important part than formerly was supposed, and that many seemingly quite different biological and pathological phenomena will find their explanation herein. Finsen takes it for granted that the peculiar sensitiveness of the skin of smallpox patients to light, a sensitiveness which he, as already mentioned, classed together with that of buckwheat exanthem, possibly can be explained along the same lines.

The investigations of Tappeiner and his pupil during the past five years upon the poisonous effects of various fluorescent fluids in light and darkness, show that the destructive effect of the substances in question, for example, upon infusoriæ, is enormously increased by the effect of light. Even when these liquids are so much diluted that in the dark they have no apparent detrimental effect upon the infusoriæ, the latter, nevertheless, will be speedily destroyed in such solutions if they are placed in the sunlight or in diffuse daylight,

[1]A description of this substance and the mode of obtaining it will be found in Mitteilungen aus Finsen's Med. Lichtinstitut, Heft IX.

which under normal conditions would not lower their vitality. The frequencies which are the most effective in this respect are those which produce fluorescence in the liquids in question. These experiments of Tappeiner were made the subject of a study by G. Busck,[1] who points out that the discovery of these phenomena happened during the same experiments with the toxicity of various preparations derived from quinin, and that the quinin preparations possess such sensitizing (sensitiveness-arousing) qualities.

The fact that frequencies otherwise fairly inactive proved themselves strongly microbicidal with regard to sensitized micro-organisms, led him to look for the power of these preparations to make the plasmodia sensitive, so that the latter are destroyed or weakened under the influence of daylight.

He bases his supposition upon the following established facts, pointing out in the same connection how simply and readily his hypothesis can be proved, viz., by exposing the quinin-saturated patient to the action of daylight or electric arc baths, preferably, however, to a source of light energy rich in the blue-violet frequencies.

In 1902 Dr. A. A. King[2] suggested that the treatment of malarial patients be carried on in the dark because many clinical and epidemic characteristics of this disease could be explained by the supposition that the sporulation of the malarial plasmodia could not take place in the dark, only in the light, and especially in the red light. He, therefore, recommended that patients should be kept in the dark or in rooms with purple or violet stained windows. This would constitute a negative phototherapy, as in the Finsen red light treatment of smallpox, i.e., the object being to cut out certain frequencies, rather than to have the action of those remaining. Although King held the opinion that the curative action of quinin bore a relation to its fluorescent proper-

[1]Mitteilungen aus Finsen's Medicinische Lysinstitut, 1904, Heft VIII.

[2]The American Journal of the Medical Sciences, Feb., 1902.

ties, he still persisted in his idea that it was the exclusion of all the frequencies most intensely active chemically which facilitated the treatment of malaria. His arguments were both ingenious and interesting, his conclusions, however, in the light of physical laws and recent biological experiment, the author believes, are wrongly drawn. In support of his theory King draws the conclusion that red light promotes the vital processes of the amœba, while violet light retards them; and as the plasmodium malariæ is a naked amœba he infers that the same thing applies to the latter. As a basis for the correctness of his hypothesis he took the experimental investigations of Harrington and Leaming,[1] which were referred to on a previous page. That part of their experiments which is of interest in this connection is summed up by the following points:

1. Amœba streams in the presence of red light.

2. Streaming is retarded, stopped or reversed by rays from the violet end of the spectrum.

3. Further, the effectiveness of the following kinds of light as inhibitors of protoplasmic flow, diminishes in the order named: white, violet, red.

The inference drawn by King that the vital processes of the amœba are retarded by the violet and promoted by the red does not seem in accord with the observed facts, for it is distinctly pointed out by Harrington and Leaming that the streaming of the protoplasm in the amœba is again continued after remaining a few minutes in any quality of light indicating that the point is the sudden change of light. In the detailed account of their experimental work nothing is said about the intensity of the light employed. So far as may be judged, however, it was evidently comparatively weak. The experiments seem to point to the fact that a transitory vigor is produced by the sudden change from a light of longer and slower wave length and less refrangibility to one of the shorter, higher and more refrangible rays,

[1]The Reactions of Lights of Different Colors. The American Journal of Physiology, August, 1899, No. 1, Vol. III.

from a less intense to a more intense light. Busck[1] in a study of King's hypothesis, states that the assumption that the inciting effect of the red frequencies, as shown by one experiment of Harrington and Leaming, is not supported by those which Dreyer has carried out at the Finsen Laboratory. Harrington and Leaming observed that a sudden change from darkness to red light brought about the movements in ten seconds, but in this experiment the possibility of a heating effect from the light energy was not precluded.

Dreyer[2] found that the blue-violet frequencies have an inciting, and in the powerful concentration, a destructive effect, while the amœbæ in the red light remain in about the same condition as in the dark.

Verworn[3] and Davenport[4] do not find the amœba proteus at all phototactic. The latter, however, finds that the amœba showed itself negatively phototactic to light of an intensity varying from strong diffuse daylight to direct sunlight.

Busck concludes that in these observations of Harrington and Leaming there is to be found no support for King's supposition that the plasmodium malariæ requires red light in order that its sporulation may be brought about.

"1. King first opposes the supposition which has hitherto been generally accepted, that the warmth of the sun, such as influences the frequency of cases of malaria, independent of the fact that a certain degree of warmth is, of course, necessary in order that the infection-carrying mosquitoes can live and preserve their activity; in this connection he refers to statements by various writers, and mentions, among other things, that negroes, whose dark skins in a particularly high degree absorb the heat rays of sunlight, possess relative immunity from malaria. When, all the same, there exists a correlation between intermittent fever and warm climates

[1]The Journal of the American Medical Sciences, July, 1904.
[2]G. Dreyer, Lysets Indvirkning paa Amöber Nuddelelser fra Finsen's medicinske Lysinstitut, 1903, Vol. V.
[3]M. Verworn, Psycho-Physiologische Protisten-studien, 1889.
[4]C. B. Davenport, Experimental Morphology, 1897.

or seasons, we must, according to King, look for the cause not in the warmth of the sun, but in the light of the sun upon which depends the sporulation of the plasmodia.

"All the conditions upon which the supposition was previously based, that warmth is an important factor in calling forth intermittent fever, may, with the same right, be held to be in favor of the view that sunlight plays a part as an etiological factor. When King, however, points out that the inhabitants of the island of Tahiti, according to Quatrefages, are free from swamp fever, although the island is only 18 degrees removed from the equator, and holds that this fact speaks against the theory of warmth being of importance, the same example may just as well be taken as a proof that neither can sunlight be the decisive factor. A more likely supposition, it seems to me, is that the conditions and nature of the soil are unfavorable for the development of anopheles, in the same way as Denmark, for instance, has gradually become so by the reclaiming of swampy land by drainage, etc.

"2. Febrile paroxysms appear, as a rule, in the daytime, and only in exceptional cases during the night. Even if febrile attacks at night occur somewhat more frequently than King supposes, it can hardly be denied that they occur with predominant frequency in the daytime, and this circumstance really does seem to speak in favor of daylight in some way or other being able to influence plasmodium malariæ; but as long as we have no accurate knowledge of the duration of the sporulation process of the plasmodia, the above fact does not tell us anything definite as to whether this effect of light is favorable or the opposite.

"3. The fact that negroes are less frequently attacked by malaria than human beings of the white race, King attributes to the dark color of their skin, which hinders the light from exercising its sporulation-inciting influence upon the plasmodia in the blood. Even if it is not out of the question that the relative immunity of the negroes may be due to entirely different causes, it must be admitted that

King has a good argument in favor of the correctness of his hypothesis, there is, however, every reason to accentuate, as Chappel does, that the clothing of civilized nations as a protection against daylight may, in many cases, to some extent, be taken as an equivalent to the dark, but often uncovered skin of the negroes.

"4. King next quotes a number of writers, according to whom the frequency of cases of illness in malarial districts decreases during periods of much rain or mists, and he connects this decrease with the lesser intensity of daylight at such periods. I must confess it seems to me more natural to explain this by the supposition that rain and mist diminish the chances of being infected by the stings of anopheles.

"5. King, after having drawn attention to various examples of spontaneous cure of malaria, and suggested that the patients in question had perhaps been treated in especially dark hospital rooms, puts forward the following hypothesis: The red corpuscles in which the plasmodia live gradually increase in size, so that some of them are at length retained in the capillaries of the skin, where sporulation is then brought about under the influence of daylight. The fever paroxysm which accompanies the process is followed by the sweating stage, during which the blood vessels of the skin are dilated, whereby the blood corpuscles therein retained are replaced, and the new generation of plasmodia is distributed to the other organs of the body.

"King looks for the potent principle of those medicines which have been used successfully against malaria in their ability to alter the optical peculiarities of the blood; some of them (Prussian blue, methylene blue) so color the blood that the rays of red light are kept away from the plasmodia, while others (quinin, esculin, fraxin) have the peculiarity in common of being fluorescent, and thereby *accentuating* the violet rays of the spectrum in the blood! According to some investigations, now more than 30 years old, by Jones, Rhoads and Pepper,[1] the blood and most of the tissues in human beings and animals are slightly fluorescent; in malarial patients this fluorescence is considerably reduced, while it again increases by the taking of quinin. King sees in this proof that the healing effect of quinin upon malaria is due to its fluorescence; he seems, however, to attach more importance to the beneficial effect of red rays upon the plasmodia than to the detrimental effect of violet rays, and he recommends the following treatment of malaria: "Keep malarial patients in dark rooms or in rooms with violet or purple windows; clothe them with garments impenetrable to light. Give the patients such remedies as render the blood dark or violet or lessen its translucency."

It is known in this disease that the blood loses its power to functionate as a radiant frequency transformer, and that the remedy for that disease is to be found in a substance which, under exposure to ultra-violet light or the higher of the visible chemical frequencies of the spectrum, absorbs the higher energy of radiation, and emits it at the lower, but still within the chemical frequencies of the spectrum. This is shown by the characteristic coloring, blue, of a solution of quinin sulphate when exposed to the chemical frequencies of light.

Quinin and several of its derivatives have been shown to have sensitizing properties as well as the phenomenon of fluorescence. These cinchona preparations exert a specific action on malaria, an action which can scarcely be explained on the ground of its toxic effect on the malarial plasmodium alone, although, according to the investigations made into its nature and mode of action, this is evidently of great importance. The question is asked by Busck, who has given the latter some considerable attention, whether it is not probable that the sensitizing properties of the quinin preparations bear a relation to the therapeutic effect. In the fact that the "specific" action of quinin is not understood, he finds

[1]Referred to by the author previously.

a reason for not leaving any of these peculiarities of condition out of consideration, and at least so well a marked one as their sensitizing power when seeking for an explanation.

Busck suggests that an inquiry as to whether daylight does not contribute at least somewhat to the successful results of the quinin treatment by killing, or at least weakening, the sensitized malarial plasmodium would be in order.

He bases his views, which are also entertained by others, upon the following facts:

(1) Quinin is fluorescent even in extreme dilutions, 1—1,000,000 and its sensitizing power is demonstrated among others by Ullmann's experiments, which show that paramœcia placed in a quinin solution 1/20000 did not die until after 5 hours when standing in the dark, while they were already killed inside of 8 minutes when he placed them in the sunlight under conditions which otherwise could not have exerted any harmful influence on paramœcia.

(2) According to Jacobson's and Dreyer's experiments light is able to exert its bactericidal action on the sensitized organism, even after passing through a layer of animal tissue. The depth to which it is able to exert this action depends, of course, among other things on the intensity of the light.

(3) The tissue elements of the human body are pellucid, and even if only a comparatively small portion of the body surface is exposed to light, the blood, and with it also the plasmodia, on account of the constant circulation, may be exposed to the influence of the light.

Busck concludes that should these hypotheses be correct, which can be readily determined by clinical examination of patients treated with quinin in light and darkness, sun baths or electric light baths would seem to be indicated in connection with the quinin treatment of malarial patients. It is interesting to note in this connection that there appeared in the current medical literature of the day, several years since, the statement that an Italian physician administered quinin to

his malarial patients, and then exposed them to the action of blue light in a room in which the ordinary clear glass was replaced by blue glass. Upon reading the report the method was practised by a physician living in Illinois upon his malarial patients, with what he felt was an unusual degree of success in the management of the same class of patients. The same medication, i.e., calomel and quinin, was exhibited as when no such exposure to the visible chemical energy of the spectrum was made. According to this physician,[1] better and more prompt results were obtained than with the classic method.

This method of sensitization has been used quite extensively by Dr. William James Morton in malignant diseases. He has utilized fluorescent substances, and especially quinin, in these cases, rendering the organism sensitive to other forms of radiating energy than the different frequencies of the spectrum, viz., the Roentgen[2] ray and radium. In the critical analysis given of the cases reported, the author is not convinced that a better showing is made from thus sensitizing the tissues before exposing them to the influence of the Roentgen or radium rays. In the average of these cases it must be borne in mind that, as a rule, they dealt with frankly incurable disease.

Busck and Dr. Siim have undertaken a number of experiments which are not yet quite finished, but which in view of the thoroughly careful and scientific work carried on at the Finsen Light Institute, at Copenhagen, cannot fail to be prolific in results for or against the theory.[3] As yet they have not yielded any positive results.

[1] Personal communication—in changing his office the journal containing the original reference was lost, therefore the name of the Italian physician is not given, but the author surmises that it is the same as the one referred to in the concluding paragraph of this chapter.

[2] It has been suggested that X rays passing through glass may by a species of fluorescence give rise to new ultra-violet rays.

[3] The beneficent action of the Danish Government in endowing the light institute of Finsen at Copenhagen cannot be too heartily commended, and the author cannot but voice the hope that the Com-

T. Catteneo, who was much impressed by d'Abbadies, remarks upon the effects of sulphur mines on paludism and some observations published about the same time, on the immunity of earth eaters from miasmatic disease conceived the possibility of combining the administration of the sulphates and fluorescent salts of quinin with exposure to light as a cure for malaria.[1]

Fluorescent Transillumination.—Fluorescent substances may be administered in suitable doses, and the patient then exposed to (1) sunlight, (2) incandescent light, (3) arc light, (4) Roentgen ray, and (5) radium for the purpose of utilizing the substance or drug to secure (1) more efficient transillumination of the tissue for diagnostic purposes (Kemp); (2) as a therapeutic measure (Busck, an Italian physician (Catteneo), and Morton). In both instances the substance used receives energy of radiation of the shortest wave length, for, as a rule, it is the violet and ultra-violet rays which undergo an alteration of refrangibility, and emits them at a longer wave length. In the case of fluorescin used by Kemp for purposes of transilluminating the stomach, the visible chemical frequencies emitted by the incandescent stomach lamp are absorbed by the fluorescin and given off at the frequencies just below, or those frequencies which in the spectrum are known by the color of green. This green fluorescence enables a much more clear and thorough investigation of the stomach outlines and conditions than simple transillumination by means of light. Its use is suggested by Kemp in cystoscopy, and it should be of value to the genito-urinary specialist.

By the use of the water-cooled vaginal lamp used for the treatment of a variety of gynæcological conditions, fluor-

monwealth of the paternal government or that of the states may see their way to a similar action.

The workers are ready, but amidst the perplexities and cares of the physician's daily life, with its never-ending problem of the wherewith, it is impossible to enter into the harvest which awaits the intelligent investigator.

[1] Med. Electrology and Radiology, April, 1904, Editorial.

escent substances in solution can at will be substituted for the water, and by closing the outflow tube of the obturator be kept within the vagina. In this way any value that the transillumination might have in diagnosis can be made use of, and at the same time the therapeutic effect of the radiant frequency transformer may be utilized. Theoretically, the method should be of value in the treatment of gonorrhœa involving the vagina, uterus, tubes even as well as the bladder, both in men and women. The method is simple enough. The fluorescence insures light, and the gonococcus, a lover of darkness, may be obliged to yield its vantage ground. The destruction of the gonococcus might take place outside of the body, or in an accessible mucous cavity. If such a bactericidal influence were exerted in the living tissue, the author believes it would be the same action as that of the short high frequencies or ultra-violet light on bacteria, an inhibiting action, for, as stated, ultra-violet frequencies act upon bacteria by reason of their short length and great frequency to shake them up, agitate them, compel them to give up little by little their energy until they are ready to cry quits. At the same time physiologic resistance is increased by their action on the blood.

Bacterial and Therapeutic Action of Phosphorescent Light.—Freund regarded it as permissible to connect the observation of Becquerel that phosphorescent plates make the infra-red frequencies visible, with certain effects of the red end of the spectrum on normal tissues. As it is proven that certain tissues are capable of fluorescence, and that the process of inducing fluorescence produces changes in the tissues, he felt all the more that this connection was admissible.

A continuous spectrum extending into the blue is given in general by the rays of phosphorescent light. The color of the radiated light is independent of the color of the exciting rays; that is, a certain luminous substance will always give off the same light whether the exciting light be blue or violet or white.

Owing to the suggestion of Becquerel and other phy-

sicists, that phosphorescent bodies under suitable experimental conditions might be made to emit direct rays capable of acting on the photographic plate after passing through opaque bodies, and in consequence to exercise the same kind of action as the Roentgen rays, Freund was induced to make some experiments with a view of testing the possible biological effect of phosphorescent light. These experiments were carried out with great care, but gave absolutely negative results. They were made upon a diffuse culture of staphylococcus pyogenes aureus, and upon a typhus culture. He concluded, therefore, that phosphorescent light of the intensity available for these experiments has no influence on bacterial growths. In the same connection he reports that C. Roth had employed the light radiated by phosphorescent bodies in various affections of the cavities and passages of the body, and that, according to his account, he had obtained favorable results in cases of chronic nasal catarrh. This Freund justly concludes could not be due, as Roth seemed inclined to believe, to a deleterious action of phosphorescent light on bacteria.

CHAPTER XXI.

The Pernicious Effect of Sunlight; Insolation. Pathological Effects of Electric Lighting.

Action of Light Energy Upon Super-sensitive Skins.

The Pernicious Effects of Sunlight upon the Normal Skin.—Under the influence of light there appears upon the skin of the higher animals certain obvious effects. Under its influence the protoplasm is reduced to keratin and the skin becomes coarser and harder. This was studied by Unna.[1] Möller's experiments referred to in Chapter VI. proved that light sets up hyperplasia of the epidermis and an abnormal horning process.

A considerable histological experimentation has shown that there are produced local pathological changes in the body cells which are subjected to powerful light energy. Many of these experiments are quoted in these pages. By the same energy there is produced even upon normal skins, changes forming a recognized pathology. By the action of light there may be produced either the hyperæmia of the skin in its different phases or the action may be upon the conjunctiva, for example. As to whether this is due to an action upon the vascular nerves or to a primary injury of the tissue cells (degenerative) is not fully established.

Workmen in electric arc light plants suffer from this untoward action of light. The occurrence of intense erythema is not infrequent.

[1]Monatsh. f. Prakt. Dermatologie, 1885, IV., p. 284.

Pathological Effects of Light Energy Acting upon Abnormal or Supersensitive Skin.—In this connection it is purposed only to treat of the conditions arising from the action of solar energy, not that from an artificial source of light energy.

The skin of some people is much more susceptible to the influence of the sun's rays than others, as is commonly noted in the ease with which they suffer from sunburn, solar erythema, and both tan and freckle pigmentation. This is much more apt to be the case with the blonde type.

There exists then an extreme susceptibility of the integument which may be (1) congenital, or (2) acquired.

Under the first head may be instanced xeroderma pigmentosum and in certain cases hydroa vernale. Under the second condition may be mentioned eczema solare. These nutritive troubles of the skin are due to a special sensibility to the chemically effective energy of light. Such skins should on physical grounds always be thin as to epidermis and smooth in texture, that is easily penetrable, in order to be so afflicted. The lesion may be either determined in this way or a pre-existing lesion may be exaggerated. This will always be much less marked on the covered part of the body as in variola.

M. Möller has studied and written of this subject of the skin lesions produced by light. Their consideration while properly belonging to dermatology, are of equal importance in considering the effect of light.

Eczema Solare.—This is a condition due to the action of chemical light energy. There may be produced in this way a typical acute eczema, with swelling, itching, œdema, or some efflorescence analogous to that of urticaria, miliary vesicles, then a diffuse oozing, or a second or subacute form which is identical with a simple subacute lichen planus. There are isolated papules, sometimes confluent at certain points. In both forms the pruritus is a constant symptom.

[1]Der Einfluss des Lichtes auf die Haut in Gesundem und Krankhaftem Zustande, Bibliotheca Medica, Stuttgart, 1900.

If not re-exposed to the action of sunlight, pigmentation does not follow the eczematous lesions.

It will be recalled that Brocq (see chapter on Concentrated Arc Light Energy) mentions a case in which an exposure of light produced so violent an eczema with œdema as to prevent the therapeutic use of light energy. The eruption is strictly limited to the unprotected parts of the body. It is very precisely limited, for example, by the hat, the collar and the waistband. It appears in the spring. It may subside under rest in the house to return upon exposure to sunlight. It may appear even in winter and summer, and even from sojourning in the house. In this event it is produced by the visible chemical frequencies which filter through the window glass.

Treatment in this condition consists of rest in the house, and protecting the parts from the action of the chemical energy of light. This may be done by the wearing of either yellow or red veils, or by protecting the face with colored paste or ointments.

The first experiment in this direction on a scientific basis was made by Th. Veiel,[1] who cured violently persistently recurring eczema solare in the case of a lady by ordering the wearing of red veils.

Summer Prurigo or Prurigo Estivale of Hutchinson.—Under this name Hutchinson described an affection of the skin affecting the uncovered parts. It was accompanied by acneiform eruptions or papules of prurigo and associated with intense pruritus. Dermatologists no longer recognize this type, and it is believed that in his description Hutchinson confounded different affections. Hutchinson did not regard it as a condition exclusively estivale. Berliner, on the other hand, attributed it to the action of the chemical solar energy.

It is not regarded by Möller, however, as a direct effect of the solar rays. He believes that it should be considered

[1]Vierteljahrschr. f. Derm. und Syph., 1897, p. 1113. Quoted by Freund.

under simple relapsing chronic prurigo of Brocq. It presents the symptomatology of this condition. In the cases published the manifestations of the disease were not limited to the uncovered part of the body. The attacks are the most intense during hot weather, but they are not absent in winter. There is no question but that the condition is aggravated by heat, but the name summer prurigo seems a misnomer.

Hydroa Vernale.—In 1860 Bazin described this rare condition, hydroa vernale or estivale. It was then forgotten until Handford described a new case of it in 1889.

The disease always begins to manifest itself in the spring time, which renders the qualifying name vernale preferable to that of estivale. Bazin described a vesiculo-bullous type, therefore the exclusive term of "vacciniform" is not only too exclusive but not good.

Since the first description quite a number of these cases have been observed, and Möller has collected 36 cases susceptible of the following grouping: (1) Vesiculo-bullous, and (2) a vacciniform variety. In common with many skin conditions, these types are not always distinctive, that is, clearly marked. They may run into one another. Again there may be an atypical variety.

The eruption appears upon the uncovered parts of the body, face and hands, and occurs in very young infants, rarely appearing after the age of 10.

In from 12 to 24 hours after exposure to vivid solar light, the first symptoms show themselves in the form of a chemical light erythema. The skin becomes red, tender, tumefied and hot. Subsequently isolated erythematous spots appear which increase in thickness and become infiltrated. Or these spots may appear without diffuse erythema. Gradually the spots become elevated, presenting a semi-transparent appearance on the top, of a clear color, forming a vesicle or bulla. Upon pricking the skin to draw out a little liquid, the cavity is not depressed, indicating that the bullæ are multilocular. As the condition progresses they extend

upon the surface at the expense of the erythematous spots, which soon appears only as a fine, red areola. The contents of the bullæ sometimes become hemorrhagic. The lesions are generally isolated, more rarely grouped and are surrounded by a common erythematous zone.

When the eruption ends as the hydroa, vesiculo-bullous variety, the contents of the bullæ become dried, a crust forms which is gradually thrown off, leaving no cicatrix. Unless there has been secondary infection of the contents of the bullæ this type of the disease leaves no trace whatever. However the disease rarely assumes this benign type.

In the vacciniform variety described by Bazin the bullæ sink slightly in the centre which assumes a deeper color becoming almost black. A clear ring around the spot indicates the remains of the bulla, this in turn is bounded by the red areola, which was present from the beginning. This is a transient appearance only, and there is subsequently observed nothing but a dry crust hard and closely attached to the skin. When this falls off it leaves a deep depressed cicatrix of a vacciniform or varioliform nature.

This form of the disease is essentially relapsing. Successive lesions appear rapidly followed by extensive and grave alterations of the skin of the uncovered parts of the body, especially of the face. The latter becomes pitted with multiple cicatrices, which are white, flat or depressed and between which there can be found telangiectases and a diffused pigmentation.

In rare instances the eruption has been observed upon covered parts of the body and the ocular mucous membranes are sometimes affected.

So profound a nutritive disturbance of the skin, of an acute type, cannot take place without systematic symptoms and there have been observed gastric phenomena, malaise and cephalalgia. These are but transient symptoms, however. McCall Anderson observed in the cases of two brothers affected with hydroa vernale a red coloration of the urine due to the presence of hæmato-porphyrine. The

same symptoms have been observed by Möller. There is no definite cure and the condition may continue until puberty.

It is concluded that the vesicles and bullæ are due to the penetration of liquid between the cells of the epidermis, thereby forming cavities isolated one from the other by the flattened cells.

There exist in the derma signs of intense inflammation with vascular lesions. The superficial lesions are infiltrated by numerous cells, the vessels dilate, the walls become necrotic, the cavities are obliterated by thrombi and hemorrhages are found at some points. The entire corresponding region of the epidermis is necrosed. This results in the formation of an eschar which becomes deeper and deeper, not ending until the whole thickness of the derma is included.

By his experiments Möller established definitely the rôle of light in the production of accidents to the skin, exclusive of any other cause. In the case of a patient affected with hydroa vernale he succeeded in producing the cutaneous condition by exposing the part to the chemically effective energy of a fifteen-ampère arc alone. The exposure of a part of the body habitually covered to this energy produced an erythema with desquamation. Repeated exposures, however, were followed by the characteristic lesions of hydroa vernale.

Under normal conditions the normal skin acquires an immunity under the influence of chemical light energy. In hydroa vernale, however, no such immunity is acquired. On the contrary the skin becomes more and more acutely sensitive. It is not noted by those who have studied this disease, whether after the erythemata is produced, the skin of these patients become pigmented as in the physiological state.

The author hazards the opinion (without observed fact) that it does not, for if it did it would shield from subsequent attacks.

As it is possible for the chemically active energy to traverse clothing to a certain extent, the presence of the

lesions on uncovered parts of the body is to be accounted for. The ability of this energy to affect superficial layers of bedclothing as demonstrated by von Esmarch (see chapter on Bacteria) is also evidence of the transparency to a certain extent of the clothing.

To produce such extensive lesions of the skin and blood vessels even, there must be very great penetration of the chemically effective energy in these cases.

Ephelides.—The pigmented spots of which this lesion consists also appear upon the uncovered regions, especially upon the face. The dorsal aspect of the hands and arms when uncovered are affected next in order, while among the laboring classes where it is the custom to leave the chest exposed upon that region also. The covered parts of the body are but little affected.

The spots are round or oval and vary in size from that of a pin head to a ten-cent piece. Sometimes they become confluent and form irregular patches. They are flat, smooth and their color varies from a clear yellow to a yellow brown. As a rule their coloring is not deep. Histologically these lesions pertain to the epidermis especially. There may be observed at the level of the mucous body numerous pigmentary granules, and there are also some pigmentary cells. The etiological relation between ephelides and the action of light is very apparent.

Zeroderma Pigmentosum.[1]—This is a very rare disease which generally runs in families and shows itself in early childhood. A congenital nutritive error in the external integument plays the most important rôle in the pathogeny of this affection. Several children in a family may be affected. The disease usually comes on in spring after exposure to sunlight of the uncovered parts.

Under the influence of sunlight as an exciting cause there appears an erythematous or eczematous dermatitis upon the face, arms and legs. Unlike sunburn, the redness goes on

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[1]Dermochromes, Jacobi-Pringle, Vol. II., p. 119.

increasing. After a time it gradually diminishes. These lesions serve as a basis for the development of numerous pigment spots of widely varying size and along with them telangiectases and warty growths which finally leave white atrophic pitted spots.

This atrophy may obtain considerable dimensions and the pigmentary spots become very numerous and extensive. The eczematous or pustular eruption tends to ulcerate and these ulcerations terminate in depressed cicatrices or keloids.

The especial feature of importance in this disease is the fact that even in early youth or even later malignant growths, carcinoma and sarcoma develop from the pigment spots and lead to secondary growths in other organs.

Diagnosis is apt to be difficult at first. Prognosis is absolutely unfavorable, and the malady may last for many years, 10 to 30.

Treatment.—This in the first place depends upon the exclusion of the frequencies of light energy active chemically. To this end yellow veils are to be worn or colored pastes used. In this way the blue frequencies are cut off. The tumors are to be removed by (1) surgical, (2) electrolytic measures. Relapses and metastases seldom fail however to recur.

Delayed Zeroderma Pigmentosum.—Unna has described the late development of cutaneous alterations identical with the preceding under the name of Carcinoma of the Skin of Sailors. At first there is observed a bluish-black condition of the skin of the uncovered regions. This is followed by isolated or confluent pigmentary or colorless spots. The skin becomes roughened and is covered in places with keratose projections. Multiple epitheliomata finally supervene, some of which have the character of cutaneous horn, while others are of a warty character. Both are destined to ulcerate and take the character of adult cutaneous epithelioma, if they have not disappeared under treatment.

Pellagra.—In this condition it is not a sensitive skin

abnormally influenced by light but a diseased skin upon which the light acts to complicate the pathological condition. It is first an erythematous cutaneous alteration then desquamating and is associated with a marked cachexia. There is great emaciation, digestive disorders or psychic manifestations. The erythema of pellagric patients is considered the most characteristic and most constant symptom. It follows the uncovered portions of the body and only comes on when the subject is cachectic, never as an initial phenomenon. In the beginning it seems like a solar erythema, coming on in spring and disappearing in the autumn. During this time it is accompanied by an erythema more or less abundant, which upon disappearance leaves the skin more shining and dry than normally.[1] It recurs in the following spring. Gradually the skin loses its elasticity and it thickens and fissures. The last stage of the disease is characterized by atrophy of the skin.[2]

According to Bouchard[3] pellagra is only a solar erythema developed in a pellagrous subject. In his experiments he showed that it was due to the chemical energy of solar light. It does not form an integral part of the syndrome pellagra, but is produced by virtue of the general state, involving as it must a malnutrition of the skin as well, rendering it susceptible to the untoward influence of light.

Variola.—Finsen's experimental work has established the action of light in the eruption of smallpox. The effect is again due to the chemical energy of light. Finsen regards the contents of the pustule of variola as very susceptible to the action of this chemical energy and that the suppurative progress is thus provoked. This is considered more at length in the chapter devoted to the exclusion of all the frequencies above the red in the treatment of smallpox and the exanthemata.

[1]Leloir and Vidal. Traite des Malades de la Peau, Paris, Mason, 1894.
[2]Raymond: Les Altérations Cutanées de la pellagra. Ann. de dermatologie, 1889, p. 267.
[3]Recherches Nouvelles sur la pellagra, Paris, 1862.

Insolation.

Insolation.—By insolation in this connection is to be understood the condition known as sunstroke, when the effect is upon the nervous system, especially upon the supreme centres.

There may be distinguished an effect from (1) the more intense thermally active energy, and (2) the more intense chemically active energy. There is a difference of opinion as to the relation between the first and the second, and the condition recognized as sunstroke.

Statistics in this latitude would seem to show a much greater preponderance of accidents of this nature in atmospheric conditions of great humidity.

The infra-red frequencies exist in greatest numbers when there is great humidity, as their amount in sunlight depends upon the amount of vapor and carbonic acid in the atmosphere. This is an atmospheric condition which is badly borne by invalids and by those in health even. It is usually remarked that the heat would be readily borne were it not for the moisture, but from the physical fact of a great quantity of heat, i.e., infra-red frequencies in connection with excess of vapor and carbonic acid, the excesses of the infra-red frequencies must be a potent factor in the depressing influence of such an atmospheric condition.

There is also a very marked lessening of the frequencies, chemically active, of the blue violet region. Such ultra-violet as are usually present in the atmosphere at the earth's surface are largely absorbed by reason of the intense humidity. Moreover, the humidity of the atmosphere by the restriction of radiation contributes to the untoward effects of the intense heat.

Möller's experiments point to an injurious effect of the thermal energy. He found that heat radiation associated with ultra-violet radiation acted as did heat radiation alone when directed on the skin of the skull of rabbits. In this way there was produced more or less intense cerebral disturbances, sometimes even sudden death. The autopsy showed, after intense irradiation, the skin of the head much swollen and a bloody, gelatinous exudation present in the subcutaneous tissue. The periosteum, the cranial bones, and the dura were discolored and covered with ecchymoses. The vessels of the brain surface were much dilated and showed numerous and in part confluent ecchymoses. When, however, the heat rays were filtered off and the ultra-violet rays alone applied no central disturbance was observable.

On the other hand, there is a good deal to say in favor of the relation between intense chemical light energy and the condition of insolation. There is also a certain clinical evidence to support this hypothesis.

In view of the well-known action of too intense chemical light energy upon plants and upon the skin and conjunctiva of man, for example, it seems rational from the physical side to believe that it must be equally effective in producing the condition of insolation which manifests itself by profound and long standing disturbances of the supreme nerve centres.

In the comparative calmness of the atmosphere, the clearness of the sky and the dryness of the air, the strongest insolation takes place. It is noted that persons become disabled in the deserts by insolation produced by excessive heat. The condition of humidity is practically unknown in arid desert regions. This would point to an action of the chemical energy of light.

In the ability of the chemical frequencies to dilate blood vessels can be found an explanation of the action of prolonged exposures to intense chemically active light energy.

If such a dilation be established superficially, it is not difficult to see how the deeper vessels of the meninges, for example, may become affected.

Insolation is an occasional cause of cerebral meningitis, influencing chiefly the convexity. The resulting meningitis is usually simple, not purulent. In cases of rapid death only indications of congestion are to be discovered.[1] Those who

[1]Gowers: Diseases of the Nervous System.

have suffered insolation rarely recover entirely from its effects. They remain very susceptible to the influence of light energy, and, in the author's experience, bright intense sunlight and the electric arc light are badly borne.

Cerebral irritability is increased under these conditions to an extreme degree. This is the more true of those whose lives are devoted to mental work. Insolation seems to be a factor in producing the neurasthenic state, and is not infrequently given as the exciting cause of insanity. Neurotics and alcoholics are much more apt to be the subjects of insolation than others, and recover from the untoward light action with difficulty.

It may be, and probably is, that there is a twofold etiological relation and, under certain conditions, both may be operative while again, as in humid atmospheric states, but the one, i.e., the thermal energy is active, while in clear dry atmospheric states with intense sunshine, the chemically active energy may be operative as an etiological factor. It is argued in behalf of the latter hypothesis that no one ever gets sunstroke from exposure to dark sources of heat, or where the luminous rays possess no degree of chemical energy, as, for example, the furnace in an arsenal. The argument is not flawless as dark heat has not the penetrating power of radiant heat, and workmen exposed to sources of intense dark heat are not infrequently overcome. Again, radiant thermal energy is not penetrative to the same degree as chemical light energy. The latter will pierce the clothing unless the color is such as to act as a filter.

In this connection the following prophylaxis of sunstroke is given. The experience of Duncan has been substantiated by that of others.

Prophylaxis of Sunstroke.—From his personal experience of sunstroke in India, Dr. Andrew Duncan[1] gives details of a method of prophylaxis which has served him well. During several successive years he suffered from severe

[1]Journal of Tropical Medicine, Aug. 15, 1902.

headaches, and during four hot seasons he had in addition intolerance of light and a tendency to unconsciousness.

Acting upon a suggestion made to him that the actinic rays, and not the heat rays of the sun, were the active agents in producing sunstroke, and that the effect would be counteracted if the body were enveloped as a photographer treats his plates in an orange-yellow wrapper, he wore an orange yellow shirt, placed a similar colored lining inside his service helmet and inside the coat over the spine. The influence of the sun was never felt to be overpowering after the use of this colored material.

The author is informed that in tropical countries yellow and red underclothing is often worn, the external dress being white. The former is used to filter out the chemical light energy, and the latter to serve as a reflecting surface.

As tissues can be made sensitive to the action of light energy by the use of suitable media, so also can they be protected from it by the use of agents which serve as filters.

The Pathological Effects of Electric Lighting.

The action of electric light must not only be considered from the physiological point of view but the pathological as well. There seems to be some difference of opinion as to the effect of electric light upon the eye and its function. However, the consensus of opinion would indicate that in electric light we have an illumination that is capable of much greater injury to the eye than gas even, and very much greater than that of an oil lamp. In the incandescent light, the mercury vapor lamp and the electric arc the chemical intensity as well as the optical intensity is considerable in amount. In the first two instances the visible chemical frequencies, and in the last both the visible and invisible chemical frequencies or ultra-violet rays are active. In the use of incandescent lamps for the purpose of house illumination, there is an irritating effect from the long continued exposure to the visible chemical frequencies, by no means a small mat-

ter when the number of lamps in use is considered and the hours during which they are used. An oil lamp on the other hand is much less rich in actinic frequencies, and gives a light richer in the yellow frequencies, which is much softer and of which the eye is much more tolerant. It is stated that a Russian medical man,[1] whose name is not given in the reference, decided that electric light was the least injurious to the eyes, basing his conclusions upon the evidence of fatigue as indicated by the closure of the lids; that is, the more frequently the lids were closed, the greater the fatigue and consequent injury. From the experiments he made he found that the lids would close with different illuminations per minute, as follows:

Candle light	6.3
Gaslight	2.8
Sunlight	2.2
Electric light	1.8

On the other hand, a number of eminent oculists in London[2] agreed that the exposure of uncovered electric light in the streets and in shops and offices, was a means of very great danger to the eyesight of the populace. Experts were so greatly exercised in this matter that they even suggested that Parliament should take it up and prohibit the use of plain glass globes for electric light, unless they were properly shaded. There is no question but that the glare of such unshaded electric lights is extremely bad for the eye in house illumination, and not only discomfort but impaired vision results from their use. The author does not think that any very great harm can be done when they are used thus unprotected in the street. The ground glass globes commonly used are made for protection in the street. Dr. Gebhardt, of Budapest, raised an emphatic protest against the practice of putting electric incandescent lamps at a low level among the wares in shop windows. He regarded this as exceed-

[1]Phil. Med. Journal.
[2]Electrical Eng., London.

ingly destructive to the eyes, and in his opinion these lamps should always be put out of the direct range of vision. Not only is the eye unfavorably affected by the action of the intensely chemical activities of light upon the nerve itself, but severe conjunctivitis, and even retinitis may occur as the result of an exposure to ultra-violet rays. The following instances illustrate this fact very clearly.

Electric Light Conjunctivitis.—According to Grimsdale,[1] this disease has received scant acknowledgment in our literature. Several cases are reported, with varying symptoms. The disease is not serious, lasting usually but a few days, and is greatly relieved by the use of compresses. It is the ultra-violet rays, and not the general illumination, which produce the effect, as is evidenced by one of the cases reported. It is thought that dark yellow glasses would be better than the ordinary smoked tint in preventing both this and snow blindness. The conjunctivitis can hardly be due to direct injury, as there is an interval of quiescence after the immediate results have passed before the acute symptoms come on. It must be due to the disturbance of the nervous system, especially the vascular centres, by direct stimulation of the afferent nerves, or the rays cause some chemic change in the conjunctiva whose products act as strong irritants, producing local inflammation.

The effect upon the conjunctiva pointed out by Grimsdale, is, the author believes, without doubt, due to the influence upon the vascular centres. The influence of the short high frequencies or intense chemically active light energy upon the capillaries, as demonstrated by the experiments of Finsen, need only to be kept in mind to prove this assertion.

The electric light conjunctivitis is of not infrequent occurrence, even from sources of intense violet as well as ultraviolet energy used therapeutically. It is the operator in this instance who is apt to suffer. This was noted by Finsen and his assistants in their earlier experiments, before experi-

[1]Medical Press and Circular, April 23, 1902.

ence had taught them to take precautions, when especially on the day following their experiments, they would suffer from red, tender and swollen skins, and the eyes felt as if full of sand, were extremely sensitive to light and the conjunctivæ injected. The author has experienced these ill effects upon the eyes in handling powerful electric arcs, and has moreover noted an intense cerebral irritability from very frequent and prolonged use of the electric arc, in her practice. These ill effects upon the eye and central nerve system are obviated by the use of colored glasses.

Ultra-Violet Ray Burns of the Eye.—Of interest in this connection, Dr. A. W. Colcord,[1] of Clariton, Penn., reports the following occurrence:

An arc, 250 volts pressure, which was used to melt a hole through a pig iron plate, gave a current of 1500 ampères. The positive pole was grounded on the iron plate and the negative was connected to a carbon 2 inches in diameter and 2 feet long, attached to a 16 foot wooden handle.

With this a 6 inch hole was melted through a 3 foot iron plate in 8 hours. During this time three of the operators received severe burns of the eyes. As they stood from 10 to 15 feet away from the arc, where the heat was not so great, it is believed that the burns were produced by the ultra-violet rays of the arc light.

Case I.—Six hours after exposure had dimness of vision. In another hour there was swelling of the eyelids, puffing and congestion of conjunctiva, marked photophobia and lachrymation, with great pain in eyeballs and burning of conjunctiva. The symptoms, increased in severity for 2 or 3 hours, gradually subsiding in 24 hours, all save the dimness of vision, which persisted for 2 weeks. During that time the patient was unable to read ordinary print or to recognize a friend across the street. As he did not return for treatment during that time, Colcord was unable to make an examination of the retina, but believed that the dimness

[1]American Electro-Therapeutic and X Ray Era, Nov., 1903.

of vision was due to retinitis. There was also in this case a burn of the first degree of the entire face, with peeling of epidermis on the day after as in sunburn.

Case II.—Same general symptoms as in No. 1, but more pain, requiring three-quarter grain morphine hypodermically. There was some dimness of vision in this case, subsiding in a day or two.

Case III.—This case was similar to others, though recovering completely in two days.

The treatment adopted in all cases was rest in bed in a darkened room. A two per cent. solution of cocaine was used, but failed to afford much relief from the pain and burning. In all of the cases an ointment of bichlorid of mercury (one grain to five ounces of sterilized vaseline) was put into the eye, but proved very irritating and was discarded. This ointment had been successfully used for some time in all ordinary burns of the conjunctiva or cornea. The greatest relief in the cases reported was obtained from application of cold sweet cream from cow's milk and from cold compresses of boric acid solution. Colcord in his summary calls attention to the following peculiar features of these cases:

(1) The extremely high candle-power of this arc light, estimated by their electrician at 480,000 or 300 times as strong as an ordinary street lamp.

(2) Length of time elapsing from exposure till effects of burn are felt, longer than an ordinary burn, shorter than an X ray burn.

(3) Pain and burning out of all proportion to visible signs of inflammation.

(4) Failure of the remedies used in an ordinary burn of the eye.

(5) Tendency to rapid and complete recovery without scarring or other permanent effects.

From the fact that glass is not transparent to ultra-violet rays, Colcord recommends that those working with similar apparatus should wear large thick spectacles of red

glass. In this way not only the ultra-violet but the blue-violet frequencies also are cut off.

In view of the therapeutic uses of powerful electric arcs and of the chemical activity of the ultra-violet rays, the cases of Colcord are of the greatest interest. Lavrand[1] reported the case of an engineer who remained exposed for about an hour at a distance of about 3 feet to the rays given out by two 15 ampère connected arcs. He stood in the cone of the rays where the light was weak but the chemical activity was greatest. Three hours afterward he felt a tingling in his eyes and soon presented all the symptoms of sunstroke, lachrymation, redness of the skin of the face and tingling, and then very severe supra-orbital neuralgia. The distance from the source of light in this case was from one-third to one-fifth of that of Colcord's cases, the current 1/500 as much: the time of exposure but one-sixth as much, and the time of development of symptoms one-half of that of Colcord's cases. There was only slight action in the eye as compared with the cases reported and the symptoms were more those of an electric sunstroke.

The same cause operated in both instances, and care should be taken in prolonged using of the electric arc not to subject the eyes and head to its intense chemical activity without suitable protection.

Electric Amblyopia.—In discussing the effect of electricity on the eyes, Galezawski[2] states that this is a lasting visual disturbance provoked by habitual exposure of the eyes to electric light indoors. He finds that the electric light can produce (1) amblyopia without any material lesion of the ocular fundus; (2) photophobia following on lachrymation due to intense retinal excitation; (3) central scotoma, simulated amblyopia, which must be recognized to avoid falling into error. These latter cases are usually in operatives who seek to obtain an increased premium. Among the

[1]Journal de Sciences Médicales de Lille, May 21, 1898.
[2]Rec. d'ophth., September; Giornale internazionale delle scienze mediche, September 30.

therapeutic measures recommended are the use of uranium spectacles and the application of cold compresses or ice bags to the eyes two or three times a day.

Color Blindness from Exposure to the Light of the Arc. —An electrical engineer,[1] after experimenting with a 45-ampère arc for about three hours, during which time no ill effects upon the eyesight were observed, left the laboratory and, on his way home, noticed that all gas and electric lights appeared to be of a deep red color. Red spots also appeared when looking in a mirror or at any polished surface.

After a day or two the red seemed to disappear and the lights appeared of a purple color for about a week, when he was again able to distinguish colors in gas and electric lights. There was no ill effect or pain accompanying this temporary color blindness, so to speak.

Another effect of the arc was to cause a severe sunburn, the skin, however, peeling worse than from a severe sunburn.

Here the exposure was to the direct energy of the arc itself as the experimental work being done required that the operator should be placed with his eyes but a few inches from the arc. The nature of the work was such that the colored glasses usually worn hampered observations, and were therefore discarded.

Concerning the ampèrage of the arc, his nearness to it and the length of the exposure, it is strange that electric light conjunctivitis was not suffered as well.

The Ignition of Ether Vapor in Presence of a Closed Electric Light.—Dwight H. Murray[2] reports that on the 19th of January, while engaged in a difficult and tedious operation his attention was taken from his work by a sudden flash of light and quick movements on the part of the anæsthetist. He found that the ether vapor had ignited, scorching the hair and eyebrow of the patient and had burned the skin on the forehead sufficiently to cause a marked red-

[1]Personal communication.
[2]New York Medical Journal and Philadelphia Medical Journal, June 27, 1903.

ness. The anæsthetist reported that, being unable to see the pupil distinctly the patient lying face downward, he turned on the electric light in order to more readily note the reaction of the pupil. The blaze was coincident with the turning on of the light. Murray states that he has never seen any such accident reported, and cautions operators not to turn electric lights on or off near the vapor of ether, particularly in a small room. In the above instance there was no exposed fire or blaze in the operating room. Upon attempting to repeat the condition experimentally he found it impossible. While his experience may not be unique it is certainly rare and the surgeon should bear in mind that it is a possibility. He concluded that ignition took place from the spark of the electric light burner made when contact took place from the turning on of the light.

The Element of Danger in the Preparation of Electric Arc Carbons.—In the preparation of carbons for the electric arc the operator is exposed to the action of the powdered carbon for many hours a day through long periods of time and the results are sometimes disastrous. While this is not a direct effect of light, it is a pathological aspect of electric lighting.

At a meeting of the Academy of Medicine, Paris, Monsieur Lancereaux[1] exhibited the lungs of a polisher of carbon terminals for the electric arc light, the said organ being transformed into veritable blocks of carbon and large vomicæ being also discovered. Up to the age of 36 years, the deceased was a vigorous stone mason. At that time he was transferred to a workshop 8 metres long by 7 broad, where with eight other men he was engaged as a polisher on stone mills, of charcoal for electric lighting purposes. The shop was so badly ventilated that sometimes the men could not distinguish each other through the charcoal and stone dust filling the atmosphere. For six years the man was employed in this way, each day's work extending to 10 or 12

[1]The Lancet, London, December 2, 1893, p. 1418.

hours. For a year before he ceased to work all together, he had coughed and expectorated black sputa. In the winter of 1890-91, he was admitted into the hospital for bronchitis after influenza, and he was then expectorating black sputa in large quantities, in which particles of carbon could easily be distinguished under the microscope and by chemical tests, i.e., resistance to strong acid. He was admitted in 1892 in an emaciated condition, and bacilli could be detected in the black sputa secreted by the numerous cavities. In reporting this case, Monsieur Lancereaux stated that every new industry that springs up is worthy of the physician's notice in the new dangers to health that may thus be created.

Illumination of Rooms in Relation to Mental Work.—The question as to whether mental work can be accomplished under the best possible conditions in a room in which only the centre of work, the writing table, etc., is brilliantly illuminated and the walls comparatively dark, is variously answered by different observers. Katz finds in discussing the subject that some assert that it is better to have dark walls upon which the eye may rest in the intervals of work, when it is fixed upon a brightly lit surface, as in reading or writing; while others say that the transition from light to darkness is not a rest to the eye, but a positive strain upon it, and hold that the walls of a study should be well illuminated as well as the table. He holds to the latter view. He finds that working in a room illuminated by a lamp that is shaded so as to exclude light from the walls produces a depressing sensation in most individuals, and gives rise in many upon whom he has experimented to a feeling of lassitude and an irresistible somnolence. On the other hand, when the walls were properly lit there was a greater capacity for work with freedom from somnolence. This increased energy and freedom from somnolence increased in proportion to the brightness of the room. His study of the subject shows that the somnolence was not due to lassitude from the day's work, but was produced merely by the abstraction of the necessary

light energy. The question is raised as to what it is in artificial light that is depressing to the nerves. Is it the incompleteness of its spectrum or the insufficiency of light as compared to darkness? Trivus, of Bechterew's[1] psychological laboratory, shows by experiments that various colored lights have depressing effects upon the rate and volume of the pulse wave. The nerves demand a certain amount of light for their activity, and as each color is but a part of the spectrum of the rays of the sun, it follows that colored light cannot give the same energy as white light. Hence, if a subject be placed in colored light he suffers from what might be called "light hunger." Thus, yellow light being in the brightest part of the spectrum does not affect the pulse rate as much as violet light, which is the darkest part of it. The writer believes, however, from his experiments on persons and their capacity for work in artificial light, that it is not the part of the spectrum that counts, but the insufficiency in the amount of light energy that acts to depress the brain and nervous system. The conclusion is reached, therefore, that the use of colored shades for softening the light in work rooms and its centralization in such a way as to leave the walls in semi-darkness, is wrong from the hygienic point of view.

On the other hand, in the author's experience, it has happened that too intense brightness of the walls of a study, has served to produce a condition of such intense cerebral irritability as to prevent the best mental effort. This may happen both in the city and the country in the summer season when the sunlight is at its brightest, but is especially apt to be the case at the seashore, where in addition to the bright light the sea serves as a mirror to reflect the light. It is also more acutely felt in those whose brains are irritable, by reason of overstrain, or where insolation has been suffered. In so far as the walls of a study illuminated by artificial light is concerned, a reasonable degree of illumination is necessary to the best mental activity. The transition from

[1]Quoted at length in Chapter VII.

light to darkness when the eye is raised momentarily, is, under these circumstances, not restful, but rather a further strain. This is especially felt when the object of the momentary change is due to the need of consulting a book of reference in the book-cases with which the study walls are usually lined. If instead of work involving mental effort, the object of the light is to enable the occupants of the room to read for diversion only, then the single unit of light, in the softly shaded light of the petroleum oil lamp, furnishes the best of illuminating devices for the eye. The same source of light is always the best for night work. The spectrum of this source of light does not act as an irritant to the eye itself as does electric light. The latter is too chemically active, even with the incandescent, for the maintenance of the best ocular and optical conditions.

Conclusion.—The entire subject of light energy in its physiologic and therapeutic relation still calls for scientific study and experiment as well as for carefully analyzed and recorded clinical observations.

That this volume may inspire and stimulate both is the author's hope.

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